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Federal Aviation Administration

Office of Aviation Policy and Plans

Washington, D.C. 20591

AD-A219 618

Establishment Criteria For Runway Visual Range System at Nonprecision Instrumented Runway

FAA-APO-88-14

November 1988

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Technical Report Documentation Page

1. Report No. FAA-APO-88-14	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Establishment Criteria for Runway Visual Range System at Nonprecision Instrumented Runway		5. Report Date November 1988 6. Performing Organization Code FAA-APO-220
7. Author(s) Ward L. Keech		8. Performing Organization Report No. FAA-APO-88-14
9. Performing Organization Name and Address U.S. Department of Transportation Federal Aviation Administration Office of Aviation Policy and Plans Washington, DC 20591		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Office of Aviation Policy and Plans Washington, DC 20591		13. Type of Report and Period Covered 14. Sponsoring Agency Code FAA

15. Supplementary Notes

Distribution Instructions: A-WYZ-2; A-X-2 (except AS/AT/FS/PL/PM); A-X (AS/AT/FS/PL/PM)-3; A-FAS-1(LTD); A-FAT-1/2/4/5/6(LTD)

16. Abstract

This report presents a benefit/cost analysis of and develops corresponding criteria for establishing Runway Visual Range (RVR) systems at nonprecision instrumented runways. The primary benefit of such investments is in the form of relief of takeoff demand on other (precision instrumented) runways. The criteria developed herein will be effected through a change to FAA Order 7031.2C, Airway Planning Standard Number One (APS-1). APS-1 contains the policy and summarizes the criteria used in determining eligibility of terminal locations for establishment, discontinuance and improvements of air navigation facilities and air traffic control services.

Applying the criteria developed herein to 106 prospective candidate airports over a 15-year planning horizon from FY 1990 through FY 2004 identifies 43 airports potentially satisfying the criteria. However, since benefit/cost criteria are only but one of several inputs to the FAA decisionmaking process relative to investment in airport facilities and equipment, ultimate site-specific investment actions must be based on all pertinent factors and considerations.

The sensitivity of the criteria results to several key assumptions is also examined.

17. Key Words Runway Visual Range, Benefit/Cost Analysis, Investment Criteria, Capital Budgeting	18. Distribution Statement Document is available from the National Technical Information Service, Springfield, Virginia 22161		
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages 68	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

EXECUTIVE SUMMARY

Over the last several years, many positive programs have been initiated to increase airside capacity at major hub airports, including such traditional expansion plans as construction of new runways, extension of existing runways, and development of taxiway systems, aprons, and gate areas. To capitalize upon and complement these programs, increased attention has been directed towards preserving and enhancing the use of existing runways. Among other approaches, this includes increasing the capability, flexibility, and capacity of current airfield systems.

Towards this end, the idea or concept of installing Runway Visual Range (RVR) Systems at nonprecision instrumented runways has been proposed as one means of enhancing airport capacity during periods of low visibility or undesirable crosswind conditions when airport acceptance rates are normally severely reduced. RVR yields the operational advantage of lower landing and takeoff minima for in-use runways. While RVR's have traditionally been installed only at precision instrumented runways, RVR-equipped nonprecision instrumented runways would provide a means of diverting (at least some) aircraft takeoff operations away from the precision instrumented runways during periods of high traffic activity and low visibility conditions. Because major losses in airport capacity occur during adverse weather conditions, there is a great need to increase the all-weather capability on many of the runways at major hub airports.

This report documents a site-specific benefit/cost analysis of establishing RVR at nonprecision instrumented runways. Based on this analysis, a benefit/cost-based investment decision model is developed for incorporation into the Aviation Data and Analysis System (ADA) in conjunction with corresponding establishment criteria for publication in FAA Order 7031.2C, Airway Planning Standard Number One (APS-1). APS-1 is a working order which contains the policy and summarizes the criteria used in determining eligibility of terminal locations for establishment, discontinuance and improvements of specified types of air navigation facilities and air traffic control services. ADA, a computer system developed and maintained by the FAA Office of Aviation Policy and Plans, facilitates APS-1 processing through its benefit/cost subroutines and supporting 4,000-plus airport database of descriptive and historical and forecast aviation activity data.

The primary benefit of an RVR dedicated to takeoff operations at a nonprecision instrumented runway is in the form of relief of takeoff demand and corresponding flight disruptions on other (precision instrumented) runways. These benefits are computed, in part, from a site-specific percentage of time when visibility conditions would allow shifting of takeoffs during busy IFR periods to the nonprecision instrumented runway with an RVR but would not allow them without it. Although this percentage of time is relatively small, the benefits can be substantial at high activity airports.

Only nonprecision instrumented runways at airports with one or more qualifying RVR-equipped precision instrumented runways and a benefit/cost ratio of one or greater will be considered establishment candidates under

the establishment criteria developed in this report. Further, the provisions of FAA Order 6560.10B, Runway Visual Range, and the siting and installation standards of FAA-STD-008 must be met. Applying these criteria to 106 prospective candidate airports over a 15-year life-cycle planning horizon from FY 1990 through FY 2004 identifies 43 airports potentially satisfying the criteria. Applying this result to average life-cycle costs of $84,200 in non-discounted constant 1988 dollars and $63,600 in constant 1988 dollars discounted to 1988 present value results in potential budgetary impacts of approximately $3.62 million and $2.73 million respectively.

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A. Introduction

Over the last several years, many positive programs have been initiated to increase airside capacity at major hub airports, including such traditional expansion plans as construction of new runways, extension of existing runways, and development of taxiway systems, aprons, and gate areas. To capitalize upon and complement these programs, increased attention has been directed towards preserving and enhancing the use of existing runways. Among other approaches, this includes increasing the capability, flexibility, and capacity of current airfield systems.

Towards this end, the idea or concept of installing Runway Visual Range (RVR) Systems on nonprecision instrumented runways has been proposed as one means of enhancing airport capacity during periods of low visibility or undesirable crosswind conditions when airport acceptance rates are normally severely reduced. RVR yields numerous operational advantages by providing lower landing and takeoff minima for in-use runways. While RVR's have traditionally been installed only on precision instrumented runways, RVR-equipped nonprecision instrumented runways would provide a means of diverting (at least some) aircraft takeoff operations away from the precision instrumented runways during periods of high traffic activity and low visibility conditions. Because major losses in airport capacity occur during adverse weather conditions, there is a great need to increase the all-weather capability on many of the runways at major hub airports.

Effective management and decisionmaking of capital investments in the National Airspace System requires, among other considerations, analysis and comparison of benefits and costs. FAA evaluates many of its investments in terminal navigation aids, communication aids, and air traffic control services by applying standard establishment and discontinuance "criteria." These criteria are summarized in FAA Order 7031.2C, Airway Planning Standard Number One - Terminal Air Navigation Facilities and Air Traffic Control Services (APS-1) (Reference 1). APS-1 is a working order which contains the policy and summarizes the criteria used in determining eligibility of terminal locations for establishment, discontinuance and improvements of specified types of air navigation facilities and air traffic control services. For less expensive equipment and facilities, the criteria are normally expressed in terms of simple traffic activity thresholds. More complex and expensive facilities and equipment are normally supported by investment criteria based on benefit versus cost considerations. A complete discussion of benefit/cost analysis as applied to FAA investment and regulatory analyses may be found in Economic Analysis of Investment and Regulatory Decisions - A Guide (Reference 2).

This report, one in a series of supporting analyses to APS-1 criteria, documents a site-specific benefit/cost analysis of Runway Visual Range (RVR) Systems for nonprecision instrumented runways. Based on this analysis, a benefit/cost-based investment decision model is developed for incorporation into the Aviation Data and Analysis System (ADA) (Reference

3) in conjunction with corresponding establishment criteria for publication in APS-1. ADA, a computer system developed and maintained by the FAA Office of Aviation Policy and Plans, facilitates APS-1 processing through its benefit/cost subroutines and supporting 4,000-plus airport database of descriptive and historical and forecast aviation activity data.

B. Kinds of Benefits and Costs

FAA's economic-based investment criteria are generally based on one or more of four categories of benefits and three categories of costs. These categories are briefly outlined below, but as indicated not all apply to RVR:

- Safety benefits accrue from investments that reduce accidents or accident risk. Since established approach and takeoff minima account for whether or not an RVR system is operating, no incremental safety benefits accrue from an RVR.

- Avoided flight disruption benefits in the form of reduced aircraft variable operating costs and passenger time savings are realized when an investment results in reducing delays, diversions, cancellations, and/or overflights. Averted flight disruptions are the principal benefit of RVR.

- Productivity benefits result when an investment reduces required resources or when it permits more to be accomplished with the same resources. RVR, in itself, does not reduce manpower or staffing requirements, but as indicated below it may reduce the workload of controllers in the airport traffic control tower.

- Other benefits can be better described and recognized qualitatively rather than quantitatively. Controllers find RVR useful because it reduces the need to make repeated human observations during periods of marginal weather conditions.

- Nonrecurring costs consist of the one-time capital expenditures incurred in the acquisition of a system. These include the costs of designing, manufacturing, installing and planning for the operation and support of the system. Nonrecurring costs, which may be either fixed or variable in nature, generally define the Research and Development (R&D) and Facilities and Equipment (F&E) budgets. Ideally, these costs should be estimated on a site-specific basis to account for the existence or lack of siting problems.

- Recurring costs consist of on-going costs required to operate and support (maintain) the system during its operational life (assumed to be 15 years in this analysis). Recurring costs, which are generally variable in nature, define the Operations and Maintenance (O&M) budget.

- Life-cycle costs are the sum of nonrecurring and recurring costs over the (economic) life of the system, normally denominated in terms of discounted present value.

C. "Critical" Values and Activity Forecasts

Standardized monetary values are assigned to benefits to provide a common basis for comparing benefits and costs. Standard unit values for these so-called "critical" values are provided in Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs (Reference 4). Critical values should be updated over time per the provisions outlined in Reference 4 to insure that the criteria reflect changes in these values and costs.

Aviation activity projected site-specifically in the FAA's Aviation Data and Analysis System (ADA) (Reference 3) is an important parameter for most benefits. Benefits and costs are computed for each year of the life-cycle (typically 15 years), discounted to present value at the 10 percent discount rate prescribed by the Office of Management and Budget (Reference 5), and summed to their present value. The useful life of the investment may be longer, but a 15 year economic life assumption results in a more conservative investment strategy with respect to obsolescence, technological and policy changes, etc.

D. How Criteria are Applied

The criteria are supported by a benefit/cost computer subroutine residing in ADA (Reference 3). FAA regional offices and other users of the criteria are encouraged to use site-specific data to the extent available, e.g., facility and equipment costs, installation costs, etc. Meeting the economic criteria is usually a necessary condition for including a site in the budget. However, when the number of qualifying sites is larger than what overall budget constraints allow, some sites may not be funded, even if economically justified. The converse is also true - locations may be excepted from meeting the economic criteria because of other factors.

E. Organization of the Remainder of this Report

The criteria developed in this report are summarized in Chapter II. Chapter III discusses the benefits of an RVR at a nonprecision instrumented runway and explains the methodology employed in quantifying and denominating them in monetary terms, followed by Chapter IV which summarizes RVR life-cycle costs. The results of applying the criteria and the corresponding budgetary impacts are outlined in Chapter V. The sensitivity of the criteria results to several key assumptions and parameters is examined in Chapter VI. Lastly, several appendices are provided which outline detailed data and supporting computations.

CHAPTER II - SUMMARY OF CRITERIA

A. Introduction

This chapter summarizes the establishment criteria for RVR at nonprecision instrumented runways and their logic and derivation, based on the detailed analyses in Chapters III (Benefits) and IV (Costs). The results of applying these criteria to 106 prospective candidate airports are outlined in Chapter V. It is important to note that satisfying the criteria does not necessarily entail or insure automatic establishment, nor does it constitute an FAA commitment. Airway Planning Standard (Reference 1) criteria are but one of several inputs to the FAA decisionmaking process relative to investment in facilities and equipment. The criteria in no way affect the responsibilities of the operating services to consider all other factors pertinent to the establishment decision.

B. Logic and Derivation of Criteria

The criteria are based on a site-specific computerized comparison of the present value of the life-cycle benefits, measured in dollars, with the present value of the life-cycle costs. A life-cycle of 15 years is assumed -- the standard economic life that is applied in most benefit/cost analyses supporting most APS-1 criteria. Life-cycle benefits and costs are derived by discounting future benefits and costs to their present value at the OMB-prescribed discount rate of 10 percent (per Reference 5) and summing. The ratio of life-cycle benefits to life-cycle costs is calculated as the basis for determining whether a runway economically qualifies as an establishment candidate for an RVR, or

$$\frac{\text{LCYBEN}}{\text{LCYCST}} \geq 1,$$

where 'LCYBEN' is the total life-cycle benefits denominated in constant dollars and discounted to present value and 'LCYCST' is the total life-cycle costs denominated in constant dollars of the same year and likewise discounted to present value. The algorithm for estimating airport-specific benefits, along with variable definitions, is outlined in Figure II-1. This algorithm is discussed in detail in Chapter III. Annual and life-cycle costs are addressed in Chapter IV. Benefit/cost subroutines for APS-1 criteria processing reside in the Aviation Data and Analysis (ADA) System (Reference 3), maintained by the FAA Office of Aviation Policy and Plans (APO). Requests for access to ADA by persons or organizations not having direct access should be made through APO's Systems and Policy Analysis Division, Economic Analysis Branch (APO-220).

In marginal cases where the benefit/cost ratio is not significantly higher or lower than the qualifying threshold (e.g., .9 or 1.1), additional screening taking into account considerations other than economics should be made. There is a significant amount of estimating that occurs in benefit/cost analysis that precludes it from being absolutely conclusive.

An allowance for estimating error should be recognized and taken into account. The RVR criteria developed in this report are based primarily on volume of air traffic and frequency and incidence of IFR weather. As

FIGURE II-1: Algorithm for Estimating Airport-Specific Benefits of RVR at Nonprecision Instrumented Runway

```
 ANNBENy                               AVERTSy                                          COSTDISRy
(Benefits,  =              (Number Averted Flight Disruptions, Yr y)            x  (Weighted Avg Cost per
 Yr y)                                                                              Flight Disruption, Yr y)
            /=====================================/\=====================================\

                 DISRUPTSWITHOUTy                                DISRUPTSWITHy
              (Number Flight Disruptions          -         (Number Flight Disruptions
               WITHOUT Investment, Yr y)                     WITH Investment, Yr y)

            /==========/\==========\               /==========/\==========\

         DELAYSWITHOUTy          DISRUPTS/DELAY        Same as DISRUPTSWITHOUTy except HRDEMAND is
       (Number Delays With-  x   (Number Flight         reduced by lesser of Z (service capacity)
       out Investment, Yr y)   Disruptions/Delay)       or HRDEMAND/2 (max divertable takeoffs)

            /=====/\=========================================================================\

    24     /         HRDEMAND                    DELAYPROP                 WINDOW           \        TWRDAYS
     \    |    (Demand for hourly        x  (Prob of an opera-   x  (Window of Opportunity:  |   x    (Tower
     /    |       operations)               tion encountering a     Portion of time during   |       Days/Yr)
 TWRHOUR=1 \                                delay of duration T)   which benefits may accrue) /

            /==========/\==========\       /=====/\=====\       /======/\======\

                              HROPNSOAG
        ANNOPNSTAFy/365     (OAG hourly opns)          X          Prob Wx <100-1/2 - <100-3/8
      (Forecast daily opns x -----------------         .          ---------------------------
       derived from TAF)       DYOPNSOAG                               Prob Wx > 100-3/8
                             (OAG daily opns)

                                                 /=====/\=====\

                                                -T*(N*Z*(1-R))
                                               e
             /==============================/\==============================\

       Where: X          Limited to a maximum of zero
              T       =  Delay threshold in hours (e.g., =>15 minutes = .25)
              N       =  Number ACTIVE precision instrumented runways (PRECRWYS/2 rounded to next higher integer)
              Z       =  Service capacity per ACTIVE precision instrumented runway:
                         22.745+(2.8333*PEAKF)+(.000416*(ANNOPNS/12))-(.02754*IFR)+(.0325*RWYS)-(3.1254*PRECRWYS)
              R       =  HRDEMAND/(N*Z)
              PEAKF   =  Peaking factor (operations during 3 busiest hours / total daily operations)
              IFR     =  Portion of time that IFR weather prevails
              RWYS    =  Number runways at airport
              PRECRWYS = Number precision instrumented runways at airport

 LCYBEN            Above process repeated each              15
(Life-Cycle   =    year of life-cycle, discounted    =     Sum  { ANNBENy x (1+d)^(y-0.5) }
 Benefits)         to present value, and summed             y=1
```

FIGURE II-1 Continued

$ANNBEN_y$ = Value of expected benefits in year 'y' in nondiscounted constant dollars

y = Each year of operational life-cycle (assumed to be 15 years)

$AVERTS_y$ = Number of averted flight disruptions estimated to result in year 'y' from the prospective RVR establishment

$COSTDISR_y$ = Weighted average cost per flight disruption in year 'y', including among other costs aircraft variable operating costs and the value of passengers'/occupants' time (see Chapter III and Appendices D and E)

$DISRUPTSWITHOUT_y$ = Number of flight disruptions estimated to result in year 'y' WITHOUT the prospective RVR establishment

$DISRUPTSWITH_y$ = Number of flight disruptions estimated to result in year 'y' WITH the prospective RVR establishment

$DELAYSWITHOUT_y$ = Number of delays estimated to result in year 'y' WITHOUT the prospective RVR establishment

DISRUPTS/DELAY = Number of flight disruptions per delay

TWRHOUR = Hour of day (0000 - 2400)

$HRDEMAND_y$ = Demand for hourly operations (for each TWRHOUR)

DELAYPROP = Probability of an operation encountering a delay of duration 'T', where 'T' is the delay threshold in hours (e.g., => 15 mins = .25)

WINDOW = Window of opportunity, or the portion of time during which benefits may accrue (periods when visibility is between 1/2 and 3/8 mile)

TWRDAYS = Number of tower operating days per year (generally 365)

$ANNOPNSTAF_y$ = Number of forecast scheduled service aircraft operations in year 'y' at the candidate airport

$HROPNSOAG_y$ = Number of hourly scheduled service aircraft operations per current OAG (Official Airline Guide) File

$DYOPNSOAG_y$ = Number of daily scheduled service aircraft operations per current OAG (Official Airline Guide) File

E = Base e

T = Duration of time constituting a delay or delay threshold, denominated as fraction of an hour (e.g., ≥ 15 minutes = .25)

N = Number of ACTIVE precision instrumented runways (PRECRWYS divided by 2, rounded to next higher integer)

Z = Service capacity per ACTIVE precision instrumented runway: 22.745 + (2.8333*PEAKF) + (0.000416*ANNOPNS/12) - (0.02754*IFR) + (0.0325*RWYS) - (3.1254*PRECRWYS)

R = HRDEMAND / (N * Z)

$PEAKF_y$ = Peaking factor - number of aircraft opns scheduled during 3 busiest hrs of the day as a proportion of daily scheduled aircraft opns

IFR = Portion of time that IFR weather prevails

RWYS = Number of runways at candidate airport

PRECRWYS = Number of precision instrumented runways at candidate airport

LCYBEN = Discounted present value of life-cycle benefits measured in constant dollars

d = Discount rate (10 percent)

0.5 = Exponent factor to effect midyear, as opposed to end-of-year, discounting

such, these criteria are general in nature and do not cover all situations which may arise. Therefore, in cases where unique site-specific operational factors exist that may warrant special considerations (e.g., troublesome terrain features in the vicinity of the airport, significant remoteness of the runway from the tower, etc.), narrative and explanatory reference should be included in the Annual Call for Estimates so that such factors may be considered in the overall investment decisionmaking process.

C. Summary of Criteria

The establishment criteria may be summarized as follows: An RVR may be installed at a nonprecision instrumented runway (i.e., not equipped with an Instrument Landing System or Microwave Landing System) provided that all the following requirements are satisfied:

a. The airport has one or more RVR-equipped precision instrumented runways. To the extent that this includes Category I runways, the first and (if applicable) second Category I runways must be equipped with and satisfy the criteria for RVR at Category I runways, as outlined Order 7031.2C (para. 22.c.(1)) and derived in Report FAA-APO-85-9. (The purpose of this criterion is to ensure that the principal and conventional needs for RVR are satisfied -- i.e., in support of operations on precision instrumented runways -- before consideration is given to the subordinate needs of RVR on nonprecision instrumented runways.)

b. The provisions of FAA Order 6560.10B, Runway Visual Range, and the siting and installation standards of FAA-STD-008 can be met.

c. The ratio of life-cycle benefits to life-cycle costs equals or exceeds one, where both benefits and costs are denominated in constant dollars of the same year at present value. Candidate runways will be screened by the benefit/cost criteria developed and outlined in this report. In cases where unique site-specific operational factors exist that may warrant special consideration (e.g., troublesome terrain features in the vicinity of the airport, significant remoteness of the runway from the tower, etc.), narrative and explanatory reference should be included in the Annual Call for Estimates so that such factors may be considered in the investment decisionmaking process. To the extent possible, site-specific costs should also be included in the Annual Call for Estimates.

Exceptions to the above criteria will be considered if supported by a staff study and the recommendation of the regional director.

D. Runway Visual Range System at Precision Instrumented Runways

Criteria for RVR at Category I precision instrumented runways is contained in Airway Planning Standard Number One, Order 7031.2C, Change 2 (Reference 1), as derived in "Establishment and Discontinuance Criteria for Runway Visual Range at Category I Precision Instrumented Runway" (Reference 6). RVR is specified as a component of Category II and Category III precision instrumented runways per Order 6560.10B, Runway Visual Range (RVR), dated May 9, 1977 (Reference 7). The criteria developed in this report and summarized in Section C above apply to RVR's on nonprecision instrumented runways.

CHAPTER III - BENEFITS OF RVR AT NONPRECISION INSTRUMENTED RUNWAYS

A. Introduction

This chapter outlines the benefits ascribable to establishing an RVR at a nonprecision instrumented runway. Benefits accrue by facilitating more takeoffs on the nonprecision instrumented runway and relieving demand on precision instrumented runways during busy, low-visibility periods. Following a brief discussion of the methods of observing and reporting visibility in Section B, an overview of RVR requirements in Section C, and a description of the underlying benefit principle in Section D, Sections E and F outline the methodology for estimating and quantifying, on a site-specific basis, annual and life-cycle benefits.

B. Methods of Observing and Reporting Visibility

There are basically two types of visibility measurements currently reported as part of the weather information for the terminal area: (1) "ground (or prevailing) visibility" measured by qualified human observers; and (2) "runway visibility value" and "runway visual range" measured by instruments:

Ground (prevailing) visibility is observed, measured, and reported by qualified human observers at a point distant from the runway - the airport traffic control tower (ATCT) or other air traffic control facility. It is defined as the greatest horizontal visibility equaled or exceeded throughout at least half the horizon circle which need not necessarily be continuous. It is measured and reported in statute miles or fractions thereof in discrete steps with the size of the steps increasing with the visibility.

Runway Visibility Value (RVV) is the visibility determined for a particular runway by instrumentation which is calibrated to indicate values comparable to those that would be seen by a human observer. It is measured and reported in statute miles or fractions thereof and is used in lieu of prevailing visibility in determining minima for a particular runway.

Runway Visual Range is also instrumentally-derived and represents the horizontal distance a pilot should be able to see on the runway itself. RVR is horizontal visual range, not slant visual range. It is reported in hundreds of feet in the increments shown in Table III-1. RVR values are displayed by equipment in the associated ATCT or other air traffic control facility and continuously updated. Touchdown RVR serves the runway touchdown zone, while Mid-RVR is located midfield of the runway and Rollout RVR near the rollout end of the runway. RVR is used in lieu of RVV and/or prevailing (meteorological) visibility in determining minima. Operationally, RVR is far superior to prevailing (meteorological) visibility and RVV.

TABLE III-1

RVR Reporting Increments

RVR (Feet)	Reporting Increments (Feet)
Below 800	100
800 - 3000	200
3000 - 6500	500

C. Overview of RVR Requirements

An overview of RVR requirements vis-a-vis runway category, weather minima, and runway lighting/marking is displayed in Table III-2. The table further indicates the sources of establishment criteria for RVR:

(1) RVR at Nonprecision Instrumented Runways in support of departure operations - the central subject of interest in this report;

(2) Touchdown RVR at Category I Precision Instrumented Runways - per Change 2 to Airway Planning Standard Number One (APS-1), Order 7031.2C (Reference 1), as derived in Establishment and Discontinuance Criteria for Runway Visual Range at Category I Precision Landing System Runway (Reference 6); and

(3) RVR at Category II and III Precision Instrumented Runways - required per Order 6560.10B (Reference 7).

Unless otherwise authorized, aircraft operating under Federal Aviation Regulation (FAR) Part 121 (domestic, flag, and supplemental air carriers and commercial operators of large aircraft), Part 123 (air travel clubs using large airplanes), Part 125 (airplanes having a seating capacity of 6,000 pounds or more), Part 129 (foreign air carriers), and Part 135 (air taxi and commercial operators) may not takeoff from a civil airport under IFR unless weather conditions are at or above the minima for IFR takeoff for that airport (Reference 8). Takeoff minima are stated as visibility only, except where the need to see and avoid an obstacle makes a ceiling value necessary.

If takeoff minima are not prescribed for a particular airport, the following standard minima apply to IFR takeoffs for aircraft operating under FAR Parts 121, 123, 125, 129 and 135: (1) for aircraft having two engines or less - 1 statute mile visibility; and (2) for aircraft having more than two engines - 1/2 statute mile visibility. On runways where standard takeoff minima are authorized, lower-than-standard minima of 1/4 mile or RVR 1600 are also authorized provided the operator's training program includes instructions on the proper procedures for accomplishing lower-than-standard takeoffs, a minimum crew of two is used, and when any of the following visual aids is

Table III-2: Overview of RVR Requirements vis-a-vis Runway Category, Weather Minima, and Runway Lighting/Marking

Category			APPROACH: Weather Minima: MDA / Dec. Hgt.	APPROACH: Weather Minima: Visibility	APPROACH: Approach Light System 1/	APPROACH: RVR 2/	APPROACH: In-Runway Lighting 3/	DEPARTURE: Visibility Minimum	DEPARTURE: RVR 2/	DEPARTURE: Runway Lighting/ Marking 3/
NON-INSTRUMENTED			1500'	3 Mi.	---	---	---	1/2-1 Mi. 7/	---	---
INSTRUMENTED	Non-Precision Instr.		290-1500'	1/2-3 Mi.	---	---	---	1/2-1 Mi. 7/	1	---
INSTRUMENTED	Precision Instr.	ILS Cat I	200'	3/4 Mi.	---	---	---	1/4 Mi.	---	HIRL or CLL or RCM
INSTRUMENTED	Precision Instr.	ILS Cat I	200'	1/2 Mi.	MALSR or SSALR or ALSF-I	---	---			
INSTRUMENTED	Precision Instr.	ILS Cat I	200'	2400 RVR	MALSR or SSALR or ALSF-I	TD 2	---	1600 RVR	TD 2	HIRL or CLL or RCM
INSTRUMENTED	Precision Instr.	ILS Cat I: A/C CAT A,B,C	200'	1800 RVR	MALSR or SSALR or ALSF-I	TD	CLL & TDZ			
INSTRUMENTED	Precision Instr.	A/C CAT D	200'	2000 RVR	MALSR or SSALR or ALSF-I	TD	CLL & TDZ			
INSTRUMENTED	Precision Instr.	ILS Cat II	150'	1600 RVR	ALSF-II	TD 3	CLL & TDZ			
INSTRUMENTED	Precision Instr.	ILS Cat II	100'	1200 RVR	ALSF-II	TD, MP 4/, & RO	CLL & TDZ	<1600 RVR - 600 RVR	TD, MP & RO /7 3	HIRL & CLL & RCM
INSTRUMENTED	Precision Instr.	ILS Cat IIIa	None	700 RVR	ALSF-II	TD, MP, & RO	CLL & TDZ			
INSTRUMENTED	Precision Instr.	ILS Cat IIIb	None	150 RVR	ALSF-II	TD 5/, MP, & RO	CLL & TDZ			
INSTRUMENTED	Precision Instr.	ILS Cat IIIc	None	None	ALSF-II	TD 5/, MP, & RO	CLL & TDZ			

1 - DISCRETIONARY PER CRITERIA DEVELOPED IN THIS REPORT & TO BE PUBLISHED IN ORDER 7031.2C, APS-1 (REF. 1)

2 - DISCRETIONARY PER CRITERIA DEVELOPED IN REPORT APO-87-9 (REF. 6) & PUBLISHED IN ORDER 7031.2C, APS-1 (REF. 1)

3 - REQUIRED PER ORDER 6560.10B (REF. 7)

1/ MALSR = Medium Intensity Approach Light System with Runway Alignment Indicator Lights; SSALR = Simplified Short Approach Light System with Sequenced Flashing Lights; ALSF = Approach Light System with Sequenced Flashing Lights in Cat I (ALSF-I) or II (ALSF-II) configuration.
2/ TD = Touchdown RVR; MP = Midpoint RVR; RO = Rollout RVR.
3/ CLL = Centerline Lights; TDZ = Touchdown Zone Lights; HIRL = High Intensity Runway Lights; RCM = Runway Centerline Markings.
4/ Midpoint RVR required only if runway is greater than 8,000 feet.
5/ RVR must be most advanced type equipment which is capable of providing readouts in 100 foot increments.
6/ The touchdown and rollout RVR are both required and controlling. Should the midpoint RVR be installed in addition to the touchdown and rollout RVR, then all 3 are controlling. However, the failure of any 1 RVR will not affect operations providing the remaining 2 RVRs are operating.
7/ 1 mi. viz. for aircraft with 2 engines or less; 1/2 mi. viz. for aircraft with more than 2 engines.

available:

a. High Intensity Runway Lights (HIRL); or

b. Runway Centerline Lights; or

c. Runway Centerline Marking; or

d. In unusual circumstances where none of the above are available, the runway is marked in such a manner that the pilot at all times has visual reference to the line of forward motion during the takeoff run.

If takeoff is based on RVR, a touchdown RVR is required and is controlling.

D. <u>The Underlying Benefits Principle</u>

Benefits accrue from an RVR whenever its availability permits a runway to be available for aircraft operations when it would otherwise be unavailable. This condition occurs during certain low visibility periods when the RVR reports more than the visibility minima while a human observer of prevailing (meteorological) visibility would report less. Differences in reported visibility result from visibility observing and reporting standards which recognize and account for relative reliability characteristics. RVR is a more reliable measurement of visibility for three reasons: first, it is located near the runway, whereas the human observer taking prevailing visibility measurements is remotely located in the ATCT or other air traffic control facility; second, it is calibrated against runway lights, as opposed to prominent objects; and third, its value is continuously measurable and available. Table III-3, as discussed in the following paragraphs, provides a comparison of comparable RVR and ground (prevailing) visibility values.

Column 1 of Table III-3 lists ground or prevailing visibilities ranging from 1/8 mile to 1 1/4 miles. Columns 2 and 3 list the maximum equivalent atmospheric transmittance value corresponding to each ground or prevailing visibility value in Column 1, based on a 250-foot baseline length and the sighting of dark objects against the horizon day sky and 25 candles light intensity at night. This conversion was taken from Table A3-7C of <u>Federal Meteorological Handbook Number One - Surface Observations</u> (Reference 9), as reproduced in Appendix A to this report.

Columns 4 through 9 of Table III-3 list maximum reportable day and night RVR values that would be computed from the transmittance factors in Columns 2 and 3, based on a 250-foot baseline length and runway light intensity settings (LS) 3 (400 candles), 4 (2,000 candles) and 5 (10,000 candles). This conversion was taken from Table A3-6B of <u>Federal Meteorological Handbook Number One - Surface Observations</u> (Reference 9), as reproduced in Appendix B to this report.

Columns 10 and 11 of Table III-3 list the maximum equivalent transmittance values corresponding to the RVR values in Columns 4 through 9, based on a 250-foot baseline length and the sighting of dark objects against the horizon day sky and 25 candles light intensity at night. Again, these

TABLE III-3

Comparison Of RVR And Ground (Prevailing) Visibility Values

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Ground (Prevailing Visibility (Mi)	Maximum Equivalent Transmittance 1/		Maximum Reportable RVR Value 2/						Maximum Equivalent Transmittance 2/		Equivalent Ground (Prevailing) Visibility 1/		Average Difference
			Day Light Setting			Night Light Setting							
	Day	Night	LS3	LS4	LS5	LS3	LS4	LS5	Day	Night	Day	Night	
2/16 (1/8)	.415	.101	0800	1000	1400	1000	1000	1200	.616	.191	5/16	3/16	2/16 (1/8)
3/16	.534	.210	1200	1400	1800	1200	1600	1800	.682	.365	6/16	5/16	2/16 (1/8)
4/16 (1/4)	.614	.309	1400	1600	2200	1600	2000	2200	.729	.454	6/16	6/16	2/16 (1/8)
5/16	.671	.394	1800	1800	2400	2000	2400	2600	.747	.524	8/16	8/16	3/16
6/16	.731	.493	2400	2400	2800	2400	2800	3500	.778	.580	8/16	8/16	2/16 (1/8)
8/16 (1/2)	.783	.590	3000	3000	3500	3000	3500	4000	.823	.670	12/16	12/16	4/16 (1/4)
10/16 (5/8)	.819	.658	3500	3500	4000	3500	4500	5000	.842	.747	12/16	14/16	3/16
12/16 (3/4)	.845	.709	4500	4500	4500	4000	5000	6000	.857	.776	14/16	16/16	3/16
14/16 (7/8)	.864	.747	5000	5000	5000	4500	6000	6000+	.870	.819	16/16	20/16	4/16 (1/4)
16/16 (1)	.879	.778	5500	5500	5500	5500	6000+	6000+	.881	.799	14/16	18/16	2/16 (1/8)
20/16 (1 1/4)	.891	.802	6000+	6000+	6000+	6000	6000+	6000+	.891	.819	20/16	20/16	2/16 (1/8)
Average (Mean)													2/16 (1/8)

1/ Source: Table A3-7C of Reference 9 (reproduced as Appendix A to this report).

2/ Source: Table A3-6B of Reference 9 (reproduced as Appendix B to this report).

values were taken from Table A3-6B of Reference 9, as reproduced in Appendix B to this report.

Columns 12 and 13 of Table III-3 list the equivalent ground or prevailing visibility value corresponding to each transmittance value in Columns 10 and 11, where Columns 12 and 13 are based on a 250-foot baseline length and the sighting of dark objects against the horizon day sky and 25 candles light intensity at night. This conversion was taken from Table A3-7C of Reference 9, as reproduced in Appendix A to this report. In other words, Columns 12 and 13 show the equivalent visibility of RVR in terms of miles. The differences between the averages of the values in Columns 12 and 13 and those in Column 1 are listed in Column 14 and constitute the basis of ascribing benefits to RVR. It is during periods of time when these visibility conditions exist -- when an RVR would report visibility equal to or greater than minima while a human observer would report less than minima -- that benefits accrue.

E. Annual Benefits

1. Introduction

A schematic of the methodology for quantifying airport-specific benefits is outlined in Figure III-1. As illustrated at the top of Figure III-1, benefits in a given year ($ANNBEN_y$) equal the number of averted flight disruptions that are estimated to result from the RVR establishment ($AVERTS_y$) multiplied by the weighted average cost per flight disruption ($COSTDISR_y$), or:

$$ANNBEN_y = AVERTS_y \times COSTDISR_y$$

The derivations of $AVERTS_y$ and $COSTDISR_y$, each of which depends on a number of further variables, are the subjects of Sections III-E-2 and III-E-3 respectively.

2. Annual Number of Averted Flight Disruptions ($AVERTS_y$)

As depicted in Figure III-1, the estimated number of averted flight disruptions in a given year ($AVERTS_y$) is the difference between the numbers of flight disruptions with the prospective RVR investment versus those without the RVR. These variables are discussed in Sections III-E-2-a and III-E-2-b below:

a. Annual Number of Flight Disruptions Without Prospective RVR Investment ($DISRUPTWITHOUT_y$)

The annual number of flight disruptions without the prospective RVR investment ($DISRUPTWITHOUT_y$) can be approximated by the product of (a) the annual number of delays without the investment ($DELAYSWITHOUT_y$) and (2) the number of flight disruptions per delay (DISRUPTS/DELAY). These variables are discussed in Sections III-E-2-a-(1) and III-E-2-a-(2) below.

FIGURE III-1: Schematic of Logic for Quantifying Airport-Specific Benefits of RVR at Nonprecision Instrumented Runway

```
 ANNBENy                              AVERTSy                                              COSTDISRy
(Benefits,  =            (Number Averted Flight Disruptions, Yr y)               x   (Weighted Avg Cost per
  Yr y)                                                                               Flight Disruption, Yr y)
              /=======================================/\=======================================\

                    DISRUPTSWITHOUTy                              DISRUPTSWITHy
                (Number Flight Disruptions          -        (Number Flight Disruptions
                 WITHOUT Investment, Yr y)                    WITH Investment, Yr y)

              /==================/\==================\     /==================/\==================\

               DELAYSWITHOUTy         DISRUPTS/DELAY         Same as DISRUPTSWITHOUTy except HRDEMAND is
              (Number Delays With-  x  (Number Flight         reduced by lesser of Z (service capacity)
              out Investment, Yr y)   Disruptions/Delay)      or HRDEMAND/2 (max divertable takeoffs)

              /========/\=========================================================================\

    24       /            HRDEMAND                          DELAYPROP              WINDOW              \     TWRDAYS
    ---      |       (Demand for hourly            x   (Prob of an opera-  x  (Window of Opportunity:  |  x   (Tower
    \        |          operations)                    tion encountering a     Portion of time during  |     Days/Yr)
 TWRHOUR=1   \                                         delay of duration T)   which benefits may accrue) /

              /==================/\==================\    /=======/\=======\    /===========/\===========\

                                      HROPNSOAG
               ANNOPNSTAFy/365      (OAG hourly opns)              X          Prob Wx <100-1/2 - <100-3/8
              (Forecast daily opns x ----------------             e           ---------------------------
               derived from TAF)       DYOPNSOAG                                  Prob Wx > 100-3/8
                                     (OAG daily opns)

                                                          /=======/\=======\

                                                             -T*(N*Z*(1-R))
                                                            e
               /===============================================/\==========================================\

               Where: X          Limited to a maximum of zero
                      T       =  Delay threshold in hours (e.g., =>15 minutes = .25)
                      N       =  Number ACTIVE precision instrumented runways (PRECRWYS/2 rounded to next higher integer)
                      Z       =  Service capacity per ACTIVE precision instrumented runway:
                                 22.745+(2.8333*PEAKF)+(.000416*(ANNOPNS/12))-(.02754*IFR)+(.0325*RWYS)-(3.1254*PRECRWYS)
                      R       =  HRDEMAND/(N*Z)
                      PEAKF   =  Peaking factor (operations during 3 busiest hours / total daily operations)
                      IFR     =  Portion of time that IFR weather prevails
                      RWYS    =  Number runways at airport
                      PRECRWYS = Number precision instrumented runways at airport

  LCYBEN        Above process repeated each              15
 (Life-Cycle =  year of life-cycle, discounted     =    Sum  { ANNBENy x (1+d)^(y-0.5) }
  Benefits)     to present value, and summed             y=1
```

(1) Annual Number of Delays Without Prospective RVR Investment ($DELAYSWITHOUT_y$)

The annual number of delays without the prospective RVR investment ($DELAYSWITHOUT_y$) is estimated by solving for each hour of the year and summing over total tower days per year (TWRDAYS) the product of (a) the hourly demand for scheduled operations (HRDEMAND); (b) the probability of an operation encountering a delay of duration 'T' based on a steady-state queuing model (DELAYPROP); and (c) the portion of time during which benefits may accrue with the prospective RVR investment (WINDOW). These variables are discussed in Sections III-E-2-a-(1)-(a), III-E-2-a-(1)-(b) and III-E-2-a-(1)-(c) below.

(a) Hourly Demand for Scheduled Operations (HRDEMAND)

The hourly demand for scheduled operations (HRDEMAND) is determined by hour by the product of (a) forecast daily operations from the Terminal Area Forecast Data Base (annual operations ($ANNOPNSTAF_y$) divided by 365 days); and (b) the ratio of that hour's scheduled operations from the Official Airline Guide (OAG) Data Base (HROPNSOAG) to daily scheduled operations from the OAG (DYOPNSOAG).

(b) Probability of an Operation Encountering a Delay (DELAYPROP)

The probability of an operation encountering a delay (DELAYPROP) is based on a steady-state queuing model, as defined in Figure III-1. The variable 'Z', representing the service capacity per active precision instrumented runway, was derived through regression analysis of the number of monthly delays equalling or exceeding 15 minutes at 22 major airports during 1985, constituting 264 observations. The implied or imputed service rate per active precision instrumented runway under IFR weather conditions was determined based on this delay data, i.e., the service rate required to explain the number of delays. Then, for each airport, the independent variables displayed in Figure III-1 were regressed against the computed service rate, with a resulting R^2 of .46 and standard error of estimate of 5.16.

For purposes of the benefit/cost screening results outlined in Chapter V of this report, the variable 'T' (duration threshold of a delay) is set to .25, denoting that only computed delays of 15 minutes or more are counted as constituting a "delay."

(c) Portion of Time During Which Benefits May Accrue (WINDOW)

Since RVR can be expected to "effectively" increase reportable visibility by 1/8 mile, as derived and explained earlier in Table III-3 and Section D of this chapter, the portion of time during which benefits may accrue (WINDOW) is the portion of time that visibility is between 1/2 mile and 3/8 mile (1/2 less 1/8) on the other hand. Several sources of site-specific visibility data are available, as described and discussed in Appendix C (e.g., References 10, 11, 12, and 13). These references or any other acceptable source may be used to determine these time percentages. If data for the candidate airport is

unavailable, data based on a nearby airport, an average of neighboring airports, or (as a last resort) national average values may be used as displayed in Table III-4.

(2) Number of Flight Disruptions per Delay (DISRUPTS/DELAY)

The purpose of this variable is to account for the fact that the model described above yields the numbers of delays with and without the prospective RVR investment, whereas conventional FAA practice is to also account for other types of flight disruption (i.e., diversions, cancellations, and overflights). For purposes of the benefit/cost screening results outlined in Chapter V, this variable is set to 1.

b. Annual Number of Flight Disruptions With Prospective RVR Investment ($DISRUPTWITH_y$)

The annual number of flight disruptions with the prospective RVR investment ($DISRUPTWITH_y$) can be solved by the very same methodology as that used for "without" the investment, as described above, except that HRDEMAND (hourly demand) is reduced by the number of operations that the candidate runway is able to absorb from the precision instrumented runways.

3. Weighted Average Cost per Flight Disruption ($COSTDISR_y$)

An FAA-APO document entitled "Benefits of Reduced Flight Disruption" (Reference 14) provides a standardized methodology for estimating the average unit costs of instrument flight disruptions -- delays, diversions, cancellations and overflights. This document, modified for specific application to RVR and updated to incorporate 1988 critical values, is reproduced as Appendix D to this report. In summary, Appendix D provides the following weighted average costs of instrument flight disruptions at hub airports in 1988 dollars:

Aircraft Operation Type	Approach	Departure
Scheduled Commercial Service	$ 10,537	$ 9,353
Nonscheduled Commercial Service	303	177
Noncommercial	196	Inappl.

F. Life-Cycle Benefits

To arrive at life-cycle benefits, the procedures outlined in Section III-E for annual benefits must be separately repeated for each year of the operational life of the investment (generally assumed to average 15 years for most APS-1 criteria), discounted to present value, and summed, or:

$$LCYBEN = \sum_{y=1}^{15} (ANNBEN_y)/((1 + d)^{y-0.5})$$

where 'y' is each year of the operational life-cycle, '$ANNBEN_y$' is the benefits in year 'y', 'd' is the OMB-prescribed discount rate of 10 percent

TABLE III-4

National Average Percentage Distributions of Weather Observations Less Than Selected Ceilings and Visibilities *

CEILING	VISIBILITY IN 16's OF A MILE																			
(Feet)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	24	32	40	48
100	0.15	0.25	0.33	0.41	0.47	0.54	0.60	0.66	0.71	0.77	0.82	0.87	0.92	0.97	1.02	1.06	1.41	1.72	2.01	2.28
200	0.25	0.41	0.54	0.66	0.77	0.87	0.97	1.06	1.16	1.24	1.33	1.41	1.49	1.57	1.65	1.72	2.28	2.78	3.24	3.68
300	0.33	0.54	0.71	0.87	1.02	1.16	1.29	1.41	1.53	1.65	1.76	1.87	1.98	2.08	2.18	2.28	3.02	3.68	4.28	4.85
400	0.41	0.66	0.87	1.06	1.24	1.41	1.57	1.72	1.87	2.01	2.15	2.28	2.41	2.54	2.66	2.78	3.68	4.48	5.21	5.90
600	0.54	0.87	1.16	1.41	1.65	1.87	2.08	2.28	2.47	2.66	2.84	3.02	3.19	3.36	3.52	3.68	4.85	5.90	6.86	7.76
800	0.66	1.06	1.41	1.72	2.01	2.28	2.54	2.78	3.02	3.24	3.46	3.68	3.88	4.09	4.28	4.48	5.90	7.17	8.33	9.40
1,000	0.77	1.24	1.65	2.01	2.35	2.66	2.96	3.24	3.52	3.78	4.04	4.28	4.53	4.76	4.99	5.21	6.86	8.33	9.66	10.90
1,200	0.87	1.41	1.87	2.28	2.66	3.02	3.36	3.68	3.99	4.28	4.57	4.85	5.12	5.39	5.65	5.90	7.76	9.40	10.90	12.29
1,500	1.02	1.65	2.18	2.66	3.10	3.52	3.91	4.28	4.64	4.99	5.32	5.65	5.96	6.27	6.57	6.86	9.01	10.90	12.62	14.21
2,000	1.24	2.01	2.66	3.24	3.78	4.28	4.76	5.21	5.65	6.07	6.47	6.86	7.24	7.61	7.97	8.33	10.90	13.16	15.21	17.09
3,000	1.65	2.66	3.52	4.28	4.99	5.65	6.27	6.86	7.43	7.37	8.50	9.01	9.50	9.98	10.45	10.90	14.21	17.09	19.67	22.03

*/ Based on functional fit of FAA-APO's Airport-Specific Data File (Reference 13).

Equation: 100 * (1 - EXP (-m * (VISIBILITY * CEILING) ^{a}))

(per Reference 5), and the 0.5 factor in the exponent of the denominator serves to effect midyear, as opposed to end-of-year, discounting. Solutions for the expression $1/(1+d)^{y-0.5}$ are provided in Table III-5 for y = 1 through 15.

TABLE III-5

Methodology for Computing the Present Value of Life-Cycle Benefits

(A)	(B)		(C)		(D)
YR (y)	Non-Discounted Annual Benefits		Mid-Pd/Yr Discount Factor @ 10% 1/		Discounted Present Value Benefits (B) x (C)
1	$ANNBEN_1$	x	.953	=	PV Ben, Yr 1
2	$ANNBEN_2$	x	.867	=	PV Ben, Yr 2
3	$ANNBEN_3$	x	.788	=	PV Ben, Yr 3
4	$ANNBEN_4$	x	.716	=	PV Ben, Yr 4
5	$ANNBEN_5$	x	.651	=	PV Ben, Yr 5
6	$ANNBEN_6$	x	.592	=	PV Ben, Yr 6
7	$ANNBEN_7$	x	.538	=	PV Ben, Yr 7
8	$ANNBEN_8$	x	.489	=	PV Ben, Yr 8
9	$ANNBEN_9$	x	.445	=	PV Ben, Yr 9
10	$ANNBEN_{10}$	x	.404	=	PV Ben, Yr 10
11	$ANNBEN_{11}$	x	.368	=	PV Ben, Yr 11
12	$ANNBEN_{12}$	x	.334	=	PV Ben, Yr 12
13	$ANNBEN_{13}$	x	.304	=	PV Ben, Yr 13
14	$ANNBEN_{14}$	x	.276	=	PV Ben, Yr 14
15	$ANNBEN_{15}$	x	.251	=	PV Ben, Yr 15
TOTAL			7.977 2/		LCYBEN

1/ Present value of $1 = $1/(1+d)^{y-0.5}$, where 'd' is the OMB-prescribed discount rate of 10 percent (per Reference 5) and 'y' is the life-cycle operating year in Column A. The '-0.5' factor serves to effect midyear, as opposed to end-of-year, discounting.

2/ Column, as printed, does not add to printed total because of independent rounding.

CHAPTER IV - RVR LIFE-CYCLE COSTS

There are three categories of costs relevant in this analysis -- nonrecurring costs, recurring costs, and life-cycle costs:

1. NONRECURRING COSTS consist of the onetime capital expenditures incurred in the acquisition of a system. These include the costs of designing and manufacturing and/or procuring, installing and planning for the system. Nonrecurring costs, which may be either fixed or variable in nature, generally are funded from the Research and Development (R&D) and Facilities and Equipment (F&E) budgets. Ideally, these costs should be estimated on a site-specific basis to account for site peculiarities.

2. RECURRING COSTS consist of on-going costs required to operate and support (maintain) the system during its operational life (assumed to be 15 years for most APS-1 criteria). Recurring costs, which are generally variable in nature, comprise the Operations and Maintenance (O&M) budget.

3. LIFE-CYCLE COSTS are the discounted present value sum of recurring and nonrecurring costs over the (economic) life of the investment (which as indicated above is assumed to average 15 years in this analysis). It is assumed that nonrecurring costs occur at the beginning of the life-cycle and therefore their present value equals their "as-spent" value. Constant dollars are used throughout this analysis and recurring costs are assumed constant for each year of the life-cycle. The present value of a uniform series of constant values is simply a cumulative discount factor times the constant annually recurring value. In this case, the cumulative discount factor over 15 years at the ten percent discount rate prescribed by the Office of Management and Budget (Reference 5) is 7.977.[1/] Letting

   F&E = nonrecurring costs, and

   O&M = recurring operation and maintenance costs,

   the present value of the life-cycle costs of an RVR, LCYCST, can be expressed as:

   $$\text{LCYCST} = \text{F\&E} + (\text{O\&M} \times 7.977).$$

1/ The cumulative discount factor, 7.977, is the sum of $1/(1+i)^{n-0.5}$ for n = 1 to 15, where 'i' is the OMB-prescribed discount rate of 10 percent (per Reference 5) and 'n' is each year of an assumed economic life of 15 years. The 0.5 factor in the exponent effects midyear, as opposed to end-of-year, discounting.

Average RVR life-cycle costs are summarized in Table IV-1 based on the technology of RVR's at the airport prior to the potential RVR establishment, i.e., the "new generation" scatter technology RVR versus the old transmissometer-based RVR. All establishments to be made under the criteria developed in this report are expected to follow "new generation" RVR establishments/replacements on precision instrumented runways. The typical life-cycle costs, therefore, are those outlined in Columns C and D of Table IV-1, $84,200 and $63,600 in non-discounted and discounted present value 1988 dollars respectively. These costs are expected or typical <u>average</u> costs. Site-specific cost estimates should be submitted in the annual Call for Estimates, reflecting site-peculiar installation costs and the year of dollars in which the costs are denominated.

TABLE IV-1

Average Life-Cycle Costs of RVR at Nonprecision Instrumented Runways 1/
(Constant 1988 Dollars in Denominations Indicated)

	(A)	(B)	(C)	(D)
	Airport WITHOUT Existing "New Generation" RVR Runway		Airport WITH Existing "New Generation" RVR Runway	
	Discounted Present Value	Nondiscounted	Discounted Present Value	Nondiscounted
NONRECURRING COSTS	$ 103,800	$ 103,800	$ 40,100	$ 40,100
RECURRING COSTS				
Annual O&M (Nondiscounted)	$ 12,250	$ 12,250	$ 2,940	$ 2,940
x 15-Year Disc. Factor 2/	x 7.977	x 15	x 7.977	x 15
Total, 15 Years 3/	$ 97,700	$ 183,800	$ 23,500	$ 44,100
TOTAL LIFE-CYCLE COSTS	$ 201,500	$ 287,600	$ 63,600	$ 84,200

1/ Sources: Updated from Reference 6 using OMB inflation factors (compounded) and APO-220 as adapted in part from Reference 15.

2/ Sum of $1/(1+i)^{n-0.5}$ for n = 1 through 15, where 'i' is the OMB-prescribed discount rate of 10 percent (per Reference 5) and 'n' is each year of an estimated economic life of 15 years. See also Table III-5.

3/ Rounded to the nearest $100.

CHAPTER V - RESULTS AND IMPACT OF CRITERIA

A. Results of Criteria

Part 1 of Table V-1 outlines site-specific results of applying the benefits and cost logic outlined in Chapters III and IV of this report to 106 prospective candidate airports. A common uniform life-cycle extending from FY 1990 through FY 2004 is applied. Of the 106 prospective candidates, 43 airports were found to satisfy the economic establishment criterion of a benefit/cost ratio of 1.0 or more. Part 2 of Table V-1 outlines other FAA towered airports that currently are not prospective candidates and reasons for noncandidacy. As indidcated in the footnote to Table V-1, Part I, all candidate runways are assumed to be usable by all aircraft. This assumption, necessitated because of database limitations, may be invalid for some airports where certain restrictions or limitations apply, such as runway length, pavement strength, noise abatement procedures, etc. In such cases, the benefits listed may be overstated.

B. Impact of Criteria

Applying average life-cycle costs of $84,200 in non-discounted constant 1988 dollars and $63,600 in constant 1988 dollars discounted to 1988 present value results in potential budgetary impacts of approximately $3.62 million and $2.73 million respectively.

TABLE V-1 - PART 1

Results of Applying Criteria - Prospective Candidates

(Sequenced by City Name)

CAUTION: SEE IMPORTANT CAVEAT IN FOOTNOTE

LOC ID	CITY	ST	NR TTL RWYS	NR PREC INSTR RWYS	NR ACTIVE PREC INSTR RWYS	SCHED CARRIER OPNS FY 90	TTL OPNS FY 90	COST PER SCHED CARRIER FLIGHT DISRUPT	PERCENT OF TIME WEATHER <= 100'/ 1/2 MI	PERCENT OF TIME WEATHER <= 100'/ 3/8 MI	SERVICING RATE/ACT-IVE PREC INSTR RWY	PEAK-ING FACTOR	LIFE-CYCLE DISCNTD BENEFITS (000 1988 (DOLLARS)	LIFE-CYCLE DISCNTD COSTS (000 1988 (DOLLARS)	LIFE-CYCLE B/C RATIO
CAK	AKRON CANTON	OH	6	3	2	12,233	151,290	$12,400	0.51	0.40	19.19	0.333	$0	$63.6	0.00
ABQ	ALBUQUERQUE	NM	8	1	1	65,387	262,156	$7,456	0.13	0.11	29.63	0.257	$8	$63.6	0.13
AMA	AMARILLO	TX	4	1	1	17,140	103,001	$8,405	0.60	0.50	23.86	0.276	$4	$63.6	0.06
ANC	ANCHORAGE INTL	AK	6	1	1	83,426	246,688	$10,076	0.46	0.39	28.73	0.205	$131	$63.6	2.06
ATL	ATLANTA INTL	GA	10	8	4	602,838	832,021	$10,667	0.82	0.67	26.91	0.222	$26,307	$63.6	413.63
AGS	AUGUSTA	GA	4	2	1	7,144	74,133	$10,542	0.62	0.51	19.70	0.319	$3	$63.6	0.05
BWI	BALTIMORE	MD	8	4	2	152,613	317,715	$8,906	0.21	0.16	21.85	0.260	$333	$63.6	5.24
BTR	BATON ROUGE	LA	4	2	1	19,524	162,288	$9,556	0.68	0.56	22.74	0.328	$9	$63.6	0.14
BED	BEDFORD	MA	4	1	1	0	269,761	$4,464	5.01	4.55	30.39	0.666	$0	$63.6	0.00
BIL	BILLINGS	MT	8	1	1	15,440	121,493	$6,839	0.39	0.32	24.78	0.312	$1	$63.6	0.02
BHM	BIRMINGHAM	AL	4	1	1	38,762	205,544	$9,303	0.15	0.11	27.15	0.238	$5	$63.6	0.08
BOI	BOISE	ID	4	1	1	15,546	178,652	$6,321	0.42	0.36	26.70	0.316	$0	$63.6	0.00
BOS	BOSTON	MA	10	5	3	254,033	458,708	$9,157	0.59	0.47	23.39	0.219	$51	$63.6	0.80
TRI	BRISTOL	TN	4	1	1	7,862	102,814	$8,132	0.89	0.76	23.77	0.271	$1	$63.6	0.02
BUF	BUFFALO	NY	4	2	1	73,177	147,883	$9,547	0.45	0.35	21.88	0.222	$680	$63.6	10.69
BTV	BURLINGTON	VT	4	1	1	14,299	156,492	$5,214	0.29	0.23	25.71	0.287	$0	$63.6	0.00
CMI	CHAMPAIGN	IL	6	1	1	5,526	171,754	$9,252	0.33	0.26	26.46	0.378	$0	$63.6	0.00
CHS	CHARLESTON AFB MUNI	SC	4	2	1	33,497	151,841	$9,366	0.56	0.46	22.33	0.285	$46	$63.6	0.72
CLT	CHARLOTTE	NC	6	4	2	221,342	415,772	$9,823	0.75	0.61	25.03	0.243	$12,281	$63.6	193.10
CHA	CHATTANOOGA	TN	4	2	1	11,340	139,117	$10,640	0.88	0.74	21.95	0.306	$4	$63.6	0.06
CYS	CHEYENNE	WY	6	1	1	813	77268	$8,242	0.59	0.49	23.42	0.421	$14	$63.6	0.22
MDW	CHICAGO MIDWAY	IL	8	3	2	115,000	305,869	$6,467	0.20	0.15	24.46	0.253	$12	$63.6	0.19
ORD	CHICAGO O'HARE	IL	14	11	6	605,076	795,338	$12,104	0.39	0.30	16.26	0.211	$10,567	$63.6	166.15
CVG	CINCINNATI GREATER	KY	6	4	2	256,666	289,445	$9,190	0.52	0.41	20.65	0.254	$6,065	$63.6	95.36
CLE	CLEVELAND HOPKINS INTL	OH	10	3	2	149,925	235,693	$9,209	0.19	0.14	22.05	0.245	$248	$63.6	3.90
CAE	COLUMBIA	SC	4	2	1	25,866	148,984	$8,788	0.55	0.45	22.17	0.272	$15	$63.6	0.24
CSG	COLUMBUS	GA	4	1	1	3,025	71,267	$14,736	0.39	0.31	22.81	0.354	$0	$63.6	0.00
CMH	COLUMBUS INTL	OH	8	3	2	100,761	261,992	$9,722	0.26	0.19	22.89	0.238	$425	$63.6	6.68
DAL	DALLAS LOVE FLD	TX	6	2	1	92,811	289,174	$6,960	0.09	0.07	27.12	0.247	$112	$63.6	1.76
DFW	DALLAS-FT WORTH	TX	12	7	4	522,349	649,378	$11,046	0.09	0.07	23.96	0.217	$2,194	$63.6	34.50
DAY	DAYTON	OH	6	4	2	117,405	225,848	$11,254	0.51	0.40	18.56	0.318	$2,667	$63.6	41.93
DAB	DAYTONA BEACH	FL	6	1	1	11,867	208,281	$7,562	0.53	0.44	27.73	0.325	$0	$63.6	0.00
DEN	DENVER STAPLETON	CO	10	5	3	392,001	549,039	$10,082	0.17	0.13	26.95	0.275	$3,456	$63.6	54.34
DSM	DES MOINES	IA	6	2	1	33,665	195,364	$8,910	0.47	0.38	23.91	0.303	$25	$63.6	0.39
DTW	DETROIT METRO WAYNE CO	MI	8	5	3	330,001	468,136	$9,968	0.52	0.41	23.83	0.279	$8,372	$63.6	131.64
DLH	DULUTH	MN	6	2	1	5,356	48,925	$16,791	2.54	2.21	18.91	0.400	$19	$63.6	0.30
EUG	EUGENE	OR	4	1	1	9,858	138,676	$9,959	1.73	1.53	25.14	0.327	$2	$63.6	0.03

CAUTION: SEE IMPORTANT CAVEAT IN FOOTNOTE

TABLE V-1 - PART 1

Results of Applying Criteria - Prospective Candidates

(Sequenced by City Name)

CAUTION: SEE IMPORTANT CAVEAT IN FOOTNOTE

LOC ID	CITY	ST	NR TTL RWYS	NR PREC INSTR RWYS	NR ACTIVE PREC INSTR RWYS	SCHED CARRIER OPNS FY 90	TTL OPNS FY 90	COST PER SCHED CARRIER FLIGHT DISRUPT	PERCENT OF TIME WEATHER <= 100'/ 1/2 MI	PERCENT OF TIME WEATHER <= 100'/ 3/8 MI	SERVICING RATE/ACT-IVE PREC INSTR RWY	PEAK-ING FACTOR	LIFE-CYCLE DISCNTD BENEFITS (000 1988 DOLLARS)	LIFE-CYCLE DISCNTD COSTS (000 1988 DOLLARS)	LIFE-CYCLE B/C RATIO
FAI	FAIRBANKS	AK	8	2	1	12,670	136,675	$3,454	0.53	0.45	22.17	0.326	$1	$63.6	0.02
FAY	FAYETTEVILLE	NC	4	1	1	9,894	70,529	$11,689	0.76	0.62	22.75	0.342	$4	$63.6	0.06
FWA	FORT WAYNE	IN	6	2	1	55,924	160,572	$9,930	0.45	0.35	22.71	0.341	$976	$63.6	15.35
FAT	FRESNO	CA	4	1	1	19,043	232,726	$7,414	1.85	1.66	28.33	0.292	$2	$63.6	0.03
GSO	GREENSBORO	NC	4	3	2	57,117	167,026	$9,634	0.75	0.61	19.53	0.253	$4	$63.6	0.06
GSP	GREENVILLE GREER	SC	4	2	1	19,696	72,970	$8,813	0.76	0.62	19.53	0.285	$27	$63.6	0.42
IAH	HOUSTON INTERCONTINENTAL	TX	8	4	2	255,008	333,389	$11,005	0.61	0.49	22.22	0.233	$16,444	$63.6	258.55
IND	INDIANAPOLIS	IN	6	4	2	88,516	248,073	$9,005	0.39	0.30	19.32	0.285	$121	$63.6	1.90
JAN	JACKSON MUNI	MS	4	2	1	20,197	103,045	$9,219	0.33	0.26	20.61	0.285	$12	$63.6	0.19
JAX	JACKSONVILLE INTL	FL	4	2	1	56,105	155,642	$8,580	1.19	1.02	22.35	0.254	$324	$63.6	5.09
AZO	KALAMAZOO	MI	6	1	1	10,254	109,203	$11,256	0.58	0.46	24.12	0.366	$2	$63.6	0.03
MCI	KANSAS CITY INTL	MO	4	3	2	148,041	228,173	$9,532	0.62	0.51	21.91	0.325	$3,463	$63.6	54.45
TYS	KNOXVILLE MCGHEE TYSON	TN	4	2	1	22,670	165,342	$8,841	0.56	0.46	22.82	0.289	$10	$63.6	0.16
LGB	LONG BEACH	CA	10	1	1	17,696	457,623	$8,042	0.99	0.81	36.10	0.309	$0	$63.6	0.00
SDF	LOUISVILLE STANDIFORD	KY	6	3	2	94,108	165,283	$9,169	0.15	0.11	19.60	0.239	$15	$63.6	0.24
MSN	MADISON	WI	8	2	1	31,537	166,317	$7,461	0.61	0.49	22.85	0.272	$22	$63.6	0.35
MFR	MEDFORD	OR	4	1	1	7,521	106,772	$15,467	1.83	1.63	24.06	0.325	$4	$63.6	0.06
MLB	MELBOURNE	FL	8	1	1	10,594	292,353	$6,694	0.53	0.44	30.81	0.358	$0	$63.6	0.00
MEM	MEMPHIS INTL	TN	10	6	3	236,984	437,766	$9,875	0.15	0.11	19.92	0.303	$2,965	$63.6	46.62
MIA	MIAMI INTL	FL	6	5	3	271,504	390,797	$10,663	0.12	0.10	21.45	0.283	$805	$63.6	12.66
MAF	MIDLAND	TX	8	1	1	18,928	123,002	$8,058	0.23	0.18	24.82	0.314	$2	$63.6	0.03
MKE	MILWAUKEE MITCHELL	WI	10	3	2	86,334	231,701	$9,092	0.75	0.61	22.05	0.286	$847	$63.6	13.32
MSP	MINNEAPOLIS ST PAUL INTL	MN	6	5	3	289,459	411,230	$10,685	0.20	0.16	21.94	0.295	$2,650	$63.6	41.67
MLI	MOLINE	IL	6	1	1	30,317	108,157	$11,209	0.33	0.26	24.04	0.303	$21	$63.6	0.33
MRY	MONTEREY	CA	4	1	1	10,332	126,248	$12,886	0.33	0.26	24.81	0.379	$1	$63.6	0.02
ACK	NANTUCKET	MA	6	1	1	0	161,307	$2,910	0.65	0.52	25.60	0.252	$0	$63.6	0.00
BNA	NASHVILLE	TN	6	3	2	126,607	300,218	$9,842	0.35	0.28	24.65	0.375	$2,055	$63.6	32.31
EWB	NEW BEDFORD	MA	4	1	1	0	134,411	$4,933	0.65	0.52	24.51	0.219	$0	$63.6	0.00
MSY	NEW ORLEANS MOISANT	LA	6	3	2	108,202	190,532	$8,920	0.42	0.34	20.46	0.231	$32	$63.6	0.50
JFK	NEW YORK-JFK	NY	10	7	4	215,881	328,393	$16,872	0.82	0.67	12.92	0.335	$2,306	$63.6	36.26
LGA	NEW YORK-LA GUARDIA	NY	6	3	2	278,358	381,407	$11,240	0.38	0.29	26.83	0.206	$7,608	$63.6	119.62
EWR	NEWARK	NJ	6	3	2	300,877	411,445	$10,621	0.38	0.29	27.98	0.248	$8,853	$63.6	139.20
SWF	NEWBURGH	NY	4	1	1	4,546	154,918	$11,844	0.53	0.42	27.52	1.000	$197	$63.6	3.10
OAK	OAKLAND INTL	CA	8	3	2	87,646	441,276	$9,373	0.47	0.37	29.14	0.241	$0	$63.6	0.00
OKC	OKLAHOMA CITY WILL ROGERS	OK	8	2	1	57,160	182,509	$8,027	0.57	0.47	23.38	0.228	$89	$63.6	1.40
OMA	OMAHA	NE	6	3	2	43,999	181,337	$8,917	0.21	0.16	20.21	0.264	$0	$63.6	0.00
ONT	ONTARIO	CA	6	2	1	93,447	159,808	$8,916	0.95	0.76	22.12	0.218	$10,993	$63.6	172.85

CAUTION: SEE IMPORTANT CAVEAT IN FOOTNOTE

TABLE V-1 - PART 1

Results of Applying Criteria - Prospective Candidates

(Sequenced by City Name)

C A U T I O N :   S E E   I M P O R T A N T   C A V E A T   I N   F O O T N O T E

LOC ID	CITY	ST	NR TTL RWYS	NR PREC INSTR RWYS	NR ACTIVE PREC INSTR RWYS	SCHED CARRIER OPNS FY 90	TTL OPNS FY 90	COST PER SCHED CARRIER FLIGHT DISRUPT	PERCENT OF TIME WEATHER <= 100'/ 1/2 MI	PERCENT OF TIME WEATHER <= 100'/ 3/8 MI	SERVICING RATE/ACT-IVE PREC INSTR RWY	PEAK-ING FACTOR	LIFE-CYCLE DISCNTD BENEFITS (000 1988 (DOLLARS)	LIFE-CYCLE DISCNTD COSTS (000 1988 (DOLLARS)	LIFE-CYCLE B/C RATIO
RIC	RICHMOND	VA	9	3	2	39,006	176,607	$7,221	0.53	0.42	20.08	0.276	$0	$63.6	0.00
ROC	ROCHESTER	NY	6	3	2	55,785	252,670	$8,276	0.20	0.16	22.63	0.252	$0	$63.6	0.00
RFD	ROCKFORD	IL	6	1	1	3,641	133,121	$20,096	0.53	0.43	25.71	0.600	$1	$63.6	0.02
SLC	SALT LAKE CITY	UT	6	3	2	187,001	361,822	$9,212	0.47	0.40	26.62	0.268	$2,166	$63.6	34.06
SAT	SAN ANTONIO INTL	TX	6	3	2	83,258	241,789	$9,249	0.39	0.30	22.09	0.228	$1	$63.6	0.02
SAN	SAN DIEGO LINDBERG	CA	4	1	1	136,977	220,397	$9,856	0.26	0.20	27.60	0.215	$4,279	$63.6	67.28
SFO	SAN FRANCISCO OAKLAND	CA	8	3	2	335,956	457,910	$11,602	0.33	0.26	29.74	0.239	$6,655	$63.6	104.64
SNA	SANTA ANA	CA	4	1	1	72,040	565,962	$10,032	0.99	0.81	39.51	0.256	$37	$63.6	0.58
SBA	SANTA BARBARA	CA	6	1	1	10,210	225,660	$11,021	0.67	0.55	28.07	0.304	$0	$63.6	0.00
SEA	SEATTLE TACOMA INTL	WA	4	2	1	207,687	312,323	$9,970	1.37	1.17	27.66	0.242	$18,906	$63.6	297.26
SHV	SHREVEPORT DOWNTOWN	LA	4	2	1	17,894	83,249	$7,653	0.41	0.33	19.88	0.260	$9	$63.6	0.14
FSD	SIOUX FALLS	SD	6	2	1	14,490	106,718	$8,401	0.47	0.38	20.92	0.333	$6	$63.6	0.09
GEG	SPOKANE INTL	WA	4	2	1	28,688	120,037	$7,772	1.65	1.44	21.13	0.267	$87	$63.6	1.37
STL	ST LOUIS INTL	MO	8	4	2	304,764	454,794	$9,867	0.20	0.15	26.57	0.263	$6,777	$63.6	106.56
SYR	SYRACUSE	NY	6	2	1	81,895	194,343	$7,499	0.27	0.21	23.87	0.294	$964	$63.6	15.16
TPA	TAMPA INTL	FL	6	3	2	159,100	270,116	$10,273	0.61	0.52	23.36	0.247	$1,100	$63.6	17.30
TUL	TULSA INTL	OK	6	3	2	58,458	224,200	$7,946	0.15	0.12	21.76	0.264	$0	$63.6	0.00
IAD	WASHINGTON DULLES	VA	8	5	3	217,918	345,015	$10,449	0.77	0.63	19.74	0.316	$6,436	$63.6	101.19
DCA	WASHINGTON NATL	VA	6	1	1	200,001	359,999	$10,021	0.21	0.16	32.[illegible]	0.206	$7,293	$63.6	114.67
ALO	WATERLOO	IA	6	1	1	0	74,512	$9,539	0.46	0.37	23.12	0.406	$0	$63.6	0.00
PBI	WEST PALM BEACH	FL	6	1	1	58,528	250,319	$8,842	0.12	0.09	29.22	0.294	$22	$63.6	0.35
ICT	WICHITA	KS	6	3	2	36,486	200,508	$8,322	0.49	0.40	20.89	0.270	$0	$63.6	0.00
[illegible]	WILMINGTON	NC	4	1	1	9,026	89,473	$8,640	0.42	0.34	23.60	0.379	$1	$63.6	0.02
[illegible]	WINDSOR LOCKS	CT	6	3	2	92,000	241,383	$8,520	0.89	0.73	22.09	0.239	$17	$63.6	0.27
ORH	WORCESTER	MA	4	1	1	4,590	126,932	$9,840	5.01	4.55	24.57	0.360	$2	$63.6	0.03

NOTE: Due to database limitations, all runways are assumed to be usable by all aircraft. This assumption may be invalid for some airports where certain restrictions or limitations apply, such as runway length, pavement strength, noise abatement procedures, etc. In such cases, the benefits listed may be overstated.

TABLE V-1 - PART 2

Results of Applying Criteria - Non-Prospective Candidates

(Sequenced by City Name)

LOC ID	CITY	ST	REASON FOR NON-PROSPECTIVE CANDIDACY
ABI	ABILENE	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
ABY	ALBANY	GA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
ALB	ALBANY	NY	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
ESF	ALEXANDRIA	LA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
ABE	ALLENTOWN	PA	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
APN	ALPENA	MI	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
ALN	ALTON	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MRI	ANCHORAGE MERRILL	AK	NO PRECISION INSTRUMENTED RUNWAYS
ARB	ANN ARBOR	MI	NO PRECISION INSTRUMENTED RUNWAYS
ATW	APPLETON	WI	NO RVRS CURRENTLY
AVL	ASHEVILLE	NC	NO RVRS CURRENTLY
ASE	ASPEN	CO	NO PRECISION INSTRUMENTED RUNWAYS
PDK	ATLANTA DEKALB PEACHTREE	GA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
FTY	ATLANTA FULTON CTY	GA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
AIY	ATLANTIC CITY BADER	NJ	NO PRECISION INSTRUMENTED RUNWAYS
ARR	AURORA	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
AUS	AUSTIN	TX	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
BFL	BAKERSFIELD	CA	NO RVRS CURRENTLY
MTN	BALTIMORE GLEN MARTIN	MD	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
BGR	BANGOR	ME	TTL RWYS = # PREC RWYS = RVR RWYS
BTL	BATTLE CREEK	MI	NO RVRS CURRENTLY
BPT	BEAUMONT PORT ARTHUR	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
BLI	BELLINGHAM	WA	NO PRECISION INSTRUMENTED RUNWAYS
BEH	BENTON HARBOR	MI	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
BET	BETHEL	AK	NO RVRS CURRENTLY
BVY	BEVERLY	MA	NO PRECISION INSTRUMENTED RUNWAYS
BGM	BINGHAMTON	NY	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
BIS	BISMARCK	ND	NO RVRS CURRENTLY
BMI	BLOOMINGTON	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
BMG	BLOOMINGTON	IN	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
BDR	BRIDGEPORT	CT	NO RVRS CURRENTLY
BJC	BROOMFIELD	CO	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
BRO	BROWNSVILLE	TX	NO RVRS CURRENTLY
BUR	BURBANK	CA	NO RVRS CURRENTLY
CDW	CALDWELL	NJ	NO PRECISION INSTRUMENTED RUNWAYS
CGI	CAPE GIRARDEAU	MO	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MDH	CARBONDALE	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CRQ	CARLSBAD	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CPR	CASPER	WY	NO RVRS CURRENTLY
CID	CEDAR RAPIDS	IA	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
CRW	CHARLESTON	WV	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
CHO	CHARLOTTESVILLE	VA	NO RVRS CURRENTLY

TABLE V-1 - PART 2

Results of Applying Criteria - Non-Prospective Candidates

(Sequenced by City Name)

LOC ID	CITY	ST	REASON FOR NON-PROSPECTIVE CANDIDACY
DPA	CHICAGO DU PAGE	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CGX	CHICAGO MEIGS	IL	NO PRECISION INSTRUMENTED RUNWAYS
PWK	CHICAGO PALWAUKEE	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CIC	CHICO	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CNO	CHINO	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LUK	CINCINNATI LUNKEN	OH	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CKB	CLARKSBURG	WV	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
BKL	CLEVELAND BURKE LAKEFRONT	OH	NO PRECISION INSTRUMENTED RUNWAYS
CGF	CLEVELAND CUYAHOGA CTY	OH	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CSM	CLINTON	OK	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
COE	COEUR D'ALENE	ID	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CLL	COLLEGE STATION	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
COS	COLORADO SPRINGS	CO	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
COU	COLUMBIA	MO	NO RVRS CURRENTLY
BAK	COLUMBUS	IN	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
OSU	COLUMBUS OHIO STATE	OH	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CCR	CONCORD	CA	NO PRECISION INSTRUMENTED RUNWAYS
CRP	CORPUS CHRISTI	TX	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
ADS	DALLAS ADDISON	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
RBD	DALLAS RED BIRD	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
DXR	DANBURY	CT	NO PRECISION INSTRUMENTED RUNWAYS
DNV	DANVILLE	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
DEC	DECATUR	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
APA	DENVER ARAPAHOE	CO	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
DET	DETROIT CITY	MI	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
YIP	DETROIT WILLOW RUN	MI	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
DHN	DOTHAN	AL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
DBQ	DUBUQUE	IA	NO RVRS CURRENTLY
CPS	EAST ST LOUIS	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
EMT	EL MONTE	CA	NO PRECISION INSTRUMENTED RUNWAYS
ELP	EL PASO	TX	NO RVRS CURRENTLY
EKM	ELKHART	IN	NO PRECISION INSTRUMENTED RUNWAYS
ELM	ELMIRA	NY	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
ERI	ERIE	PA	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
EVV	EVANSVILLE	IN	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
PAE	EVERETT	WA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
FFZ	FALCON/MESA	AZ	NO PRECISION INSTRUMENTED RUNWAYS
FAR	FARGO	ND	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
FRG	FARMINGDALE	NY	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
FMN	FARMINGTON	NM	NO PRECISION INSTRUMENTED RUNWAYS
FYV	FAYETTEVILLE	AR	NO PRECISION INSTRUMENTED RUNWAYS
FNT	FLINT	MI	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
FLO	FLORENCE	SC	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA

TABLE V-1 - PART 2

Results of Applying Criteria - Non-Prospective Candidates

(Sequenced by City Name)

LOC ID	CITY	ST	REASON FOR NON-PROSPECTIVE CANDIDACY
FLL	FORT LAUDERDALE	FL	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
FXE	FORT LAUDERDALE EXEC	FL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
FMY	FORT MYERS PAGE FLD	FL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
RSW	FORT MYERS REGIONAL	FL	NO RVRS CURRENTLY
FSM	FORT SMITH	AR	NO RVRS CURRENTLY
FTW	FORT WORTH	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
FUL	FULLERTON	CA	NO PRECISION INSTRUMENTED RUNWAYS
GNV	GAINESVILLE	FL	NO RVRS CURRENTLY
GAL	GALENA	AK	NO PRECISION INSTRUMENTED RUNWAYS
GBG	GALESBURG	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
GYY	GARY	IN	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
GYR	GOODYEAR	AZ	NO PRECISION INSTRUMENTED RUNWAYS
GCN	GRAND CANYON	AZ	NO RVRS CURRENTLY
GFK	GRAND FORKS	ND	NO RVRS CURRENTLY
GRI	GRAND ISLAND	NE	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
GJT	GRAND JUNCTION	CO	NO RVRS CURRENTLY
GRR	GRAND RAPIDS	MI	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
GTF	GREAT FALLS	MT	NO RVRS CURRENTLY
GRB	GREEN BAY	WI	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
GVT	GREENVILLE	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
GLH	GREENVILLE	MS	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
GMU	GREENVILLE MUNI	SC	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
GON	GROTON	CT	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
GPT	GULFPORT	MS	NO RVRS CURRENTLY
HGR	HAGERSTOWN	MD	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HRL	HARLINGEN	TX	NO RVRS CURRENTLY
CXY	HARRISBURG CAPITAL CITY	PA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MDT	HARRISBURG MIDDLETOWN INTL	PA	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
HFD	HARTFORD	CT	NO PRECISION INSTRUMENTED RUNWAYS
HHR	HAWTHORNE	CA	NO PRECISION INSTRUMENTED RUNWAYS
HWD	HAYWARD	CA	NO PRECISION INSTRUMENTED RUNWAYS
HLN	HELENA	MT	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HKY	HICKORY	NC	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HIO	HILLSBORO	OR	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
ITO	HILO	HI	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HOB	HOBBS	NM	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HWO	HOLLYWOOD	FL	NO PRECISION INSTRUMENTED RUNWAYS
HNL	HONOLULU	HI	NO RVRS CURRENTLY
HUM	HOUMA	LA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HOU	HOUSTON HOBBY	TX	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
DWH	HOUSTON TOMBALL DW HOOKS	TX	NO PRECISION INSTRUMENTED RUNWAYS
HTS	HUNTINGTON	WV	NO RVRS CURRENTLY
HSV	HUNTSVILLE	AL	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED

TABLE V-1 - PART 2

Results of Applying Criteria - Non-Prospective Candidates

(Sequenced by City Name)

LOC ID	CITY	ST	REASON FOR NON-PROSPECTIVE CANDIDACY
HUT	HUTCHINSON	KS	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HYA	HYANNIS	MA	NO RVRS CURRENTLY
IDA	IDAHO FALLS	ID	NO RVRS CURRENTLY
ISP	ISLIP	NY	NO RVRS CURRENTLY
ITH	ITHICA	NY	NO RVRS CURRENTLY
JXN	JACKSON	MI	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HKS	JACKSON HAWKINS	MS	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CRG	JACKSONVILLE CRAIG FLD	FL	NO PRECISION INSTRUMENTED RUNWAYS
JVL	JANESVILLE	WI	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
JLN	JOPLIN	MO	NO RVRS CURRENTLY
JNU	JUNEAU	AK	NO PRECISION INSTRUMENTED RUNWAYS
OGG	KAHULUI	HI	NO RVRS CURRENTLY
KOA	KAILUA-KONA	HI	NO RVRS CURRENTLY
MKC	KANSAS CITY MUNI	MO	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
KCK	KANSAS CITY (NOT IN ADA)	KS	NO PRECISION INSTRUMENTED RUNWAYS
MKK	KAUNAKAKAI-MOLOKAI	HI	NO PRECISION INSTRUMENTED RUNWAYS
ENA	KENAI	AK	NO RVRS CURRENTLY
EYW	KEY WEST	FL	NO PRECISION INSTRUMENTED RUNWAYS
AKN	KING SALMON	AK	NO RVRS CURRENTLY
ISO	KINSTON	NC	NO RVRS CURRENTLY
LMT	KLAMATH FALLS	OR	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
DKX	KNOXVILLE	TN	NO PRECISION INSTRUMENTED RUNWAYS
ADQ	KODIAK	AK	NO RVRS CURRENTLY
POC	LA VERNE	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LSE	LACROSS	WI	NO RVRS CURRENTLY
LAF	LAFAYETTE	IN	NO RVRS CURRENTLY
LFT	LAFAYETTE	LA	NO RVRS CURRENTLY
LCH	LAKE CHARLES	LA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LAL	LAKELAND	FL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LNS	LANCASTER	PA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
WJF	LANCASTER	CA	NO PRECISION INSTRUMENTED RUNWAYS
LAN	LANSING	MI	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LRD	LAREDO	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LAS	LAS VEGAS MCCARRAN INTL	NV	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LBE	LATROBE	PA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LWM	LAWRENCE	MA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LAW	LAWTON	OK	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LEB	LEBANON	NH	NO RVRS CURRENTLY
LWB	LEWISBURG	WV	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LWS	LEWISTON	ID	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LEX	LEXINGTON	KY	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
LIH	LIHUE	HI	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA

TABLE V-1 - PART 2

Results of Applying Criteria - Non-Prospective Candidates

(Sequenced by City Name)

LOC ID	CITY	ST	REASON FOR NON-PROSPECTIVE CANDIDACY
LNK	LINCOLN	NE	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
LIT	LITTLE ROCK	AR	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
LVK	LIVERMORE	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
GGG	LONGVIEW	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
LAX	LOS ANGELES INTL	CA	TTL RWYS = # PREC RWYS = RVR RWYS
LOU	LOUISVILLE BOWMAN	KY	NO PRECISION INSTRUMENTED RUNWAYS
LBB	LUBBOCK	TX	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
LYH	LYNCHBURG	VA	NO RVRS CURRENTLY
MCN	MACON	GA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MHT	MANCHESTER	NH	NO RVRS CURRENTLY
MFD	MANSFIELD	OH	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MWA	MARION	IL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MVY	MARTHAS VINEYARDS	MA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MRB	MARTINSBURG	WV	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MYV	MARYSVILLE	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MFE	MC ALLEN	TX	NO RVRS CURRENTLY
MCE	MERCED	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MEI	MERIDIAN KEY	MS	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
TNT	MIAMI DADE-COLLIER	FL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MWC	MILWAUKEE TIMMERMAN	WI	NO PRECISION INSTRUMENTED RUNWAYS
MIC	MINNEAPOLIS CRYSTAL	MN	NO PRECISION INSTRUMENTED RUNWAYS
FCM	MINNEAPOLIS FLYING CLOUD	MN	NO PRECISION INSTRUMENTED RUNWAYS
MOT	MINOT	ND	NO RVRS CURRENTLY
MSO	MISSOULA	MT	NO RVRS CURRENTLY
MOB	MOBILE	AL	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
MOD	MODESTO	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MLU	MONROE	LA	NO RVRS CURRENTLY
MGM	MONTGOMERY	AL	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
MGW	MORGANTOWN	WV	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MMU	MORRISTOWN	NJ	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MWH	MOSES LAKE	WA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MIE	MUNCIE	IN	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
MKG	MUSKEGON	MI	NO RVRS CURRENTLY
APC	NAPA	CA	NO PRECISION INSTRUMENTED RUNWAYS
HVN	NEW HAVEN	CT	NO RVRS CURRENTLY
NEW	NEW ORLEANS LAKEFRONT	LA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
PHF	NEWPORT NEWS	VA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
IAG	NIAGARA FALLS	NY	
ORF	NORFOLK	VA	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
VGT	NORTH LAS VEGAS	NV	NO PRECISION INSTRUMENTED RUNWAYS
CRE	NORTH MYRTLE BEACH	SC	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
PNE	NORTH PHILADELPHIA	PA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
OWD	NORWOOD	MA	NO PRECISION INSTRUMENTED RUNWAYS

TABLE V-1 - PART 2

Results of Applying Criteria - Non-Prospective Candidates

(Sequenced by City Name)

LOC ID	CITY	ST	REASON FOR NON-PROSPECTIVE CANDIDACY
OGD	OGDEN	UT	NO PRECISION INSTRUMENTED RUNWAYS
PWA	OKLAHOMA CITY WILEY POST	OK	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
OJC	OLATHE	KS	NO PRECISION INSTRUMENTED RUNWAYS
OLM	OLYMPIA	WA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
OPF	OPA LOCKA	FL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
ORL	ORLANDO EXEC	FL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
OSH	OSHKOSH	WI	NO RVRS CURRENTLY
OWB	OWENSBORO	KY	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
OXR	OXNARD	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
PAH	PADUCAH	KY	NO RVRS CURRENTLY
PSP	PALM SPRINGS	CA	NO PRECISION INSTRUMENTED RUNWAYS
PMD	PALMDALE	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
PAO	PALO ALTO	CA	NO PRECISION INSTRUMENTED RUNWAYS
PFN	PANAMA CITY	FL	NO RVRS CURRENTLY
PKB	PARKERSBURG	WV	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
PSC	PASCO	WA	NO RVRS CURRENTLY
PDT	PENDLETON	OR	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
DVT	PHOENIX DEER VALLEY	AZ	NO PRECISION INSTRUMENTED RUNWAYS
PHX	PHOENIX SKY HARBOR	AZ	NO RVRS CURRENTLY
PBF	PINE BLUFF	AR	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
AGC	PITTSBURGH ALLEGHENY	PA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
PIH	POCATELLO	ID	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
PMP	POMPANO BEACH	FL	NO PRECISION INSTRUMENTED RUNWAYS
PTK	PONTIAC	MI	NO RVRS CURRENTLY
PWM	PORTLAND	ME	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
POU	POUGHKEEPSIE	NY	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
PRC	PRESCOTT	AZ	NO PRECISION INSTRUMENTED RUNWAYS
PUB	PUEBLO	CO	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
RDU	RALEIGH-DURHAM	NC	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
RAP	RAPID CITY	SD	NO RVRS CURRENTLY
RDG	READING	PA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
RDD	REDDING	CA	NO RVRS CURRENTLY
RNO	RENO INTL	NV	NO RVRS CURRENTLY
RNT	RENTON	WA	NO PRECISION INSTRUMENTED RUNWAYS
RAL	RIVERSIDE	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
ROA	ROANOKE	VA	NO RVRS CURRENTLY
RST	ROCHESTER	MN	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
ROW	ROSWELL	NM	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
SAC	SACRAMENTO EXEC	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
SMF	SACRAMENTO METRO	CA	TTL RWYS = # PREC RWYS = RVR RWYS
MBS	SAGINAW	MI	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
SLE	SALEM	OR	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
SLN	SALINA	KS	NO RVRS CURRENTLY

TABLE V-1 - PART 2

Results of Applying Criteria - Non-Prospective Candidates

(Sequenced by City Name)

LOC ID	CITY	ST	REASON FOR NON-PROSPECTIVE CANDIDACY
SNS	SALINAS	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
SJT	SAN ANGELO	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
SSF	SAN ANTONIO STINSON	TX	NO PRECISION INSTRUMENTED RUNWAYS
SQL	SAN CARLOS	CA	NO PRECISION INSTRUMENTED RUNWAYS
SDM	SAN DIEGO BROWN FLD	CA	NO PRECISION INSTRUMENTED RUNWAYS
MYF	SAN DIEGO MONTGOMERY	CA	NO RVRS CURRENTLY
SEE	SAN DIEGO/EL CAJON GILLESPI	CA	NO PRECISION INSTRUMENTED RUNWAYS
SJC	SAN JOSE MUNI	CA	NO RVRS CURRENTLY
RHV	SAN JOSE REID HILLVIEW	CA	NO PRECISION INSTRUMENTED RUNWAYS
SJU	SAN JUAN INTL	PR	NO RVRS CURRENTLY
SIG	SAN JUAN ISLA GRANDE	PR	NO PRECISION INSTRUMENTED RUNWAYS
SFB	SANFORD	FL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
SAF	SANTA FE	NM	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
SMX	SANTA MARIA	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
SMO	SANTA MONICA	CA	NO PRECISION INSTRUMENTED RUNWAYS
STS	SANTA ROSA	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
SRQ	SARASOTA	FL	NO RVRS CURRENTLY
SAV	SAVANNAH	GA	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
SDL	SCOTTSDALE	AZ	NO PRECISION INSTRUMENTED RUNWAYS
BFI	SEATTLE BOEING	WA	NO RVRS CURRENTLY
SUX	SIOUX CITY	IA	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
SBN	SOUTH BEND	IN	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
TVL	SOUTH LAKE TAHOE	CA	NO PRECISION INSTRUMENTED RUNWAYS
SFF	SPOKANE FELTS FLD	WA	NO PRECISION INSTRUMENTED RUNWAYS
SGF	SPRINGFIELD	MO	NO RVRS CURRENTLY
SPI	SPRINGFIELD	IL	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
STX	ST CROIX	VI	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
STJ	ST JOSEPH	MO	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
SUS	ST LOUIS SP OF ST LOUIS	MO	NO RVRS CURRENTLY
STP	ST PAUL	MN	NO PRECISION INSTRUMENTED RUNWAYS
PIE	ST PETERSBURG CLEARWATER	FL	NO RVRS CURRENTLY
SPG	ST PETERSBURG WHITT	FL	NO PRECISION INSTRUMENTED RUNWAYS
STT	ST THOMAS CHAR AMAL HS TRUM	VI	NO RVRS CURRENTLY
SCK	STOCKTON	CA	NO RVRS CURRENTLY
TIW	TACOMA	WA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
TLH	TALLAHASSEE	FL	
TMB	TAMIAMI	FL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HUF	TERRE HAUTE	IN	NO RVRS CURRENTLY
TEB	TETERBORO	NJ	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
TXK	TEXARKANA	AR	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
TIX	TITUSVILLE	FL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
TOL	TOLEDO	OH	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
FOE	TOPEKA FORBES AFB	KS	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA

TABLE V-1 - PART 2

Results of Applying Criteria - Non-Prospective Candidates

(Sequenced by City Name)

LOC ID	CITY	ST	REASON FOR NON-PROSPECTIVE CANDIDACY
TOP	TOPEKA PHILIP BILLARD	KS	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
TOA	TORRANCE	CA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
TVC	TRAVERSE CITY	MI	NO RVRS CURRENTLY
TTN	TRENTON	NJ	NO RVRS CURRENTLY
TTD	TROUTDALE	OR	NO PRECISION INSTRUMENTED RUNWAYS
TOI	TROY	AL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
TUS	TUCSON	AZ	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
RVS	TULSA RIVERSIDE	OK	NO PRECISION INSTRUMENTED RUNWAYS
TCL	TUSCALOOSA	AL	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
TWF	TWIN FALLS	ID	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
TYR	TYLER	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
UCA	UTICA	NY	NO RVRS CURRENTLY
VLD	VALDOSTA	GA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
VNY	VAN NUYS	CA	NO RVRS CURRENTLY
VRB	VERO BEACH	FL	NO PRECISION INSTRUMENTED RUNWAYS
ACT	WACO	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
CNW	WACO	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
ALW	WALLA WALLA	WA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
BAF	WESTFIELD	MA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
FOK	WESTHAMPTON BEACH	NY	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HLG	WHEELING	WV	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
HPN	WHITE PLAINS	NY	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED
SPS	WICHITA FALLS	TX	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
AVP	WILKES BARRE	PA	NO RVRS CURRENTLY
IPT	WILLIAMSPORT	PA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
ILG	WILMINGTON	DE	
INT	WINSTON SALEM	NC	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
YKM	YAKIMA	WA	CAT I RWY(S) DON'T SATISFY CAT I RVR CRITERIA
YNG	YOUNGSTOWN	OH	>= 2 CAT I ILS, ONLY 1 RVR-EQUIPPED

CHAPTER VI - SENSITIVITY ANALYSIS

The criteria developed in this report, as well as the results and budgetary impact of their application, are significantly dependent on several key assumptions, estimates and forecasts. To provide a perspective of the sensitivity of the criteria and their results/impact to these parameters, a sensitivity analysis was performed by varying selected parameters by various percentages (while keeping all other variables unchanged) and observing the changes and results in the aggregate. This analysis was performed for those parameters having the greatest influence on the results and impact of the criteria and for those parameters which are somewhat judgmental in nature. Table VI-1 below outlines the results.

TABLE VI-1

Sensitivity Analysis Summary

Parameter and Variation	Total Number of Airports With B/C Ratio = or > 1
Minutes of delay that constitute a flight disruption ('T' or delay threshold)	
67% decrease (5 minutes)	79
33% decrease (10 minutes)	56
No Change (15 minutes)	43
33% increase (20 minutes)	39
100% increase (30 minutes)	36
200% increase (45 minutes)	34
300% increase (60 minutes)	32
Increased interval of time RVR permits runway to be open for takeoffs (site-specific)	
50% decrease	39
25% decrease	43
10% decrease	43
No Change	43
10% increase	43
25% increase	44
50% increase	45
Probability of encountering a delay of 15 minutes or more	
50% decrease	39
25% decrease	43
No Change	43
25% increase	44
50% increase	45

TABLE VI-1 (Continued)

Sensitivity Analysis Summary

Parameter and Variation	Total Number of Airports With B/C Ratio = or > 1
Hourly value of aircraft passengers'/ occupants' time	
100% decrease ($0.00)	38
No Change ($24.50)	43
25% increase	43
Cost of a Flight Disruption	
75% decrease	36
50% decrease	39
25% decrease	43
No Change	43
10% increase	43
25% increase	44
50% increase	45
75% increase	46
Nonrecurring costs	
50% decrease ($20,050)	45
25% decrease ($30,075)	43
No Change ($40,100)	43
50% increase ($60,150)	43
100% increase ($80,200)	41
Annual operations and support costs	
50% decrease ($1,470)	43
No Change ($2,940)	43
100% increase ($5,880)	43
Total life-cycle costs	
50% decrease ($1,470)	47
25% decrease ($2,205)	44
No Change ($2,940)	43
25% increase ($3,675)	43
50% increase ($4,410)	41
100% increase ($5,880)	39

REFERENCES

1. FAA Order 7C31.2C, Airway Planning Standard Number One, Terminal Air Navigation Facilities and Air Traffic Control Services.

2. Economic Analysis of Investment and Regulatory Decisions - A Guide, Report Number FAA-APO-82-1, January 1982.

3. Aviation Data and Analysis System (ADA), maintained by the FAA's Office of Aviation Policy and Plans (FAA-APO-110).

4. Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs, Report Number FAA-APO-81-3, September 1981. Updated in APO Bulletin APO-84-3, same title.

5. Discount Rates to be Used in Evaluating Time-Distributed Costs and Benefits, Circular A-94 (Revised), Office of Management and Budget, March 27, 1972.

6. Establishment and Discontinuance Criteria for Runway Visual Range at Category I Precision Landing System Runway, Report Number FAA-APO-87-9, January 1987.

7. Order 6560.10B.

8. Code of Federal Regulations, Title 14, Aeronautics and Space.

9. Federal Meteorological Handbook Number One, Surface Observations, Second Edition, Departments of Commerce, Defense and Transportation January 1, 1979.

10. Climatic Studies for Proposed Landing Systems, Volumes 1-32, Report Number FAA-ARD-64-54, June 1964.

11. Ceiling-Visibility Climatological Study and Systems Enhancement Factors, prepared for the FAA by the National Climatic Center (Asheville, NC), Report Number DOT-FA75WAI-547, June 1975.

12. Wind-Ceiling-Visibility Data at Selected Airports, Volumes 1-11, National Climatic Center (Asheville, NC), April 1981.

13. Airport-Specific Data File, Aviation Data Analysis System, database maintained by the FAA Office of Aviation Policy and Plans.

14. "Benefits of Reduced Flight Disruption", FAA Office of Aviation Policy and Plans, Systems Analysis Division, 1982. Originally published in Report Number FAA-APO-82-10, Establishment and Discontinuance Criteria for Precision Landing Systems, June 1983.

15. "Runway Visual Range Life-Cycle Cost Comparison," Martin Marietta Corporation, October 31, 1985.

APPENDIX A

Runway Visibility From Transmissometer Conversion Table For 250-Foot Baseline*

DAY			NIGHT		
Corrected Transmissometer Reading		Visibility	Corrected Transmissometer Reading		Visibility
From	To		From	To	
.013*	.231	1/16	.018#	.101	1/8
.232	.415	1/8	.102	.210	3/16
.416	.534	3/16	.211	.309	1/4
.535	.614	1/4	.310	.394	5/16
.615	.671	5/16	.395	.493	3/8
.672	.731	3/8	.494	.590	1/2
.732	.783	1/2	.591	.658	5/8
.784	.819	5/8	.659	.709	3/4
.820	.845	3/4	.710	.747	7/8
.846	.864	7/8	.748	.778	1
.865	.879	1	.779	.802	1 1/8
.880	.891	1 1/8	.803	.822	1 1/4
.892	.901	1 1/4	.823	.839	1 3/8
.902	.909	1 3/8	.840	.853	1 1/2
.910	.916	1 1/2	.854	.865	1 5/8
.917	.922	1 5/8	.866	.875	1 3/4
.923	.927	1 3/4	.876	.884	1 7/8
.928	.932	1 7/8	.885	.896	2
.933	.937	2	.897	.908	2 1/4
.938	.944	2 1/4	.909	.922	2 1/2
.945	.951	2 1/2	.923	.942	3
.952	.962	3	.943	.957	4
.963	.970	4	.958	.966	5
.971	.975	5	.967	.972	6
.976	.979	6	.973	.977	7
.980	.982	7	.978	.980	8
.983	.984	8	.981	.983	9
.985	.986	9	.984	.985	10
.987	.987	10			

*If reading is less than .013, report the visibility at 1/16-

#If reading is less than .018, report visibility as 1/8-

Computation based on the sighting of dark objects against the horizon sky during day and 25cp light intensity at night.

*Source: Table A3-7C of Federal Meteorological Handbook Number One, Surface Observations, Second Edition, Departments of Commerce, Defense and Transportation, January 1, 1979.

APPENDIX B

RVR-Transmission Conversion Table for 250-Foot Baseline*

Night					Day				
RVR (Ft)	LS 5	LS 4	LS 3	(AF) Other	RVR (Ft)	LS 5	LS 4	LS 3	(AF) Other
0600-	.001	.003	.007	.018	0600-	.030	.067	.150	.235
0600	.011	.020	.036	.064	0600	.104	.184	.328	.355
0800	.035	.055	.086	.126	0800	.197	.309	.447	.447
1000	.071	.102	.147	.192	1000	.290	.419	.517	.517
1200	.113	.155	.211	.255	1200	.375	.511	.572	.572
1400	.159	.208	.272	.314	1400	.448	.586	.617	.617
1600	.205	.259	.329	.366	1600	.511	.647	.653	.653
1800	.249	.308	.381	.413	1800	.564	.683	.683	.683
2000	.291	.353	.427	.455	2000	.610	.708	.708	.708
2200	.331	.394	.469	.492	2200	.650	.730	.730	.730
2400	.367	.432	.507	.525	2400	.684	.748	.748	.748
2600	.401	.466	.541	.555	2600	.714	.764	.764	.764
2800	.433	.497	.571	.581	2800	.739	.779	.779	.779
3000	.482	.546	.617	.622	3000	.777	.800	.800	.800
3500	.541	.603	.671	.671#	3500	.819	.824	.824	.824
4000	.591	.649	.714	.714#	4000	.843	.843	.843	.843
4500	.632	.687	.748	.748#	4500	.858	.858	.858	.858
5000	.666	.719	.777	.777#	5000	.871	.871	.871	.871
5500	.696	.746	.800	.800#	5500	.882	.882	.882	.882
6000	.721	.769	.820	.820#	6000	.890	.890	.890	.890
6000+					6000+				

NOTES:

1. Before entering this table with transmissivity value:

   a. Subtract background illumination.

   b. Divide by five if value was obtained while in HIGH mode.

2. (AF) Use column labeled "Other" when runway lights are not operating on LS 3, 4 or 5; e.g., turned off, inoperative, or otherwise not available.

3. Values identified by "#" were adjusted to accomplish necessary compatibility between respective equations.

*Source: Table A3-6B of Federal Meteorological Handbook Number One, Surface Observations, Second Edition, Departments of Commerce, Defense and Transportation, January 1, 1979.

APPENDIX C

Weather Data for Evaluation of Actual or Effective Mimima Reduction Benefits

At least four data sources provide statistics for specific airports from historical weather records showing the percentages of time the weather is at or below given categories or combinations of ceiling and/or visibility:

- Climatic Studies for Proposed Landing Systems (Reference C-1) provides percentages of time ceilings are less than 100, 200, 300, 400, 500, 600, 800, 1,000, 1,500, 2,000 and 3,000 feet, and visibilities are less than 1/16, 1/8, 1/4, 1/2, 3/4, 1, 1-1/2, and 3 miles. The report is relatively detailed in terms of ceiling and visibility categories, but provides data on only 32 North American airports.

- Ceiling-Visibility Climatological Study and System Enhancement Factors (Reference C-2) provides, for 271 airports, percentages of hourly weather observations falling within six ceiling and visibility combinations: (1) greater than or equal to 1,500 feet and 3 miles; (2) less than 1,500 feet and/or 3 miles; (3) less than 1,500 feet and/or 3 miles, but equal to or greater than 400 feet and 1 mile; (4) less than 400 feet and/or 1 mile, but equal to or greater than 200 feet and 1/2 mile; (5) less than 200 feet and/or 1/2 mile, but equal to or greater than 100 feet and 1/4 mile; and (6) less than 100 feet and/or 1/4 mile. Compared to Reference C-1, there is less detail on specific ceilings and visibilities, but more sites.

- Wind-Ceiling-Visibility Data at Selected Airports (Reference C-3) provides, for 283 airports, data on the same ceiling and visibility combinations in Reference C-2, and additionally provides wind direction data.

- The Airport-Specific Data File (Reference C-4), maintained by the FAA Office of Aviation Policy and Plans (FAA-APO), contains actual and estimated weather probabilities within eight ceiling (C) and visibility (V) combinations for over 1,600 airports, as follows:

$C \leq 200$ or $V \leq 0.50$
$C \leq 300$ or $V \leq 0.75$, but $C > 200$ and $V > 0.50$
$C \leq 400$ or $V \leq 1.00$, but $C > 300$ and $V > 0.75$
$C \leq 600$ or $V \leq 1.50$, but $C > 400$ and $V > 1.00$
$C \leq 800$ or $V \leq 2.00$, but $C > 600$ and $V > 1.50$
$C \leq 1{,}000$ or $V \leq 2.50$, but $C > 800$ and $V > 2.00$
$C \leq 1{,}200$ or $V \leq 3.00$, but $C > 1{,}000$ and $V > 2.50$
$C \leq 1{,}500$ or $V \leq 3.00$, but $C > 1{,}200$ and $V > 2.50$

This file, an integrated database supporting the Aviation Data and Analysis System (ADA) (Reference C-5), is used for APS-1 criteria processing. Table III-4 in the text of this report outlines a matrix of national average weather probabilities based on a best functional fit of this database.

In instances where weather data is unavailable or limited, interpolation and/or analogous analysis may be necessary to determine required weather variables. Any of the above sources may be used, as appropriate and available. If data on a given candidate airport is not available from any of these or other acceptable sources, data based on a nearby airport, an average of neighboring airports, or as a last resort the national average from Table III-4 may be used. Reference C-4 is relied upon for actual ADA benefit/cost processing unless overridden by other data.

References for Appendix C

C-1. Climatic Studies for Proposed Landing Systems, Volumes 1-32, Report Number FAA-ARD-64-54, June 1964.

C-2. Ceiling-Visibility Climatological Study and System Enhancement Factors, prepared for the FAA by the National Climatic Center (Asheville, NC), Report Number DOT-FA75WAI-547, June 1975.

C-3. Wind-Ceiling-Visibility Data at Selected Airports, Volumes 1-11, National Climatic Center, April 1981.

C-4. Airport-Specific Data File, database supporting Reference C-5 and maintained by the FAA Office of Aviation Policy and Plans (FAA-APO).

C-5. Aviation Data and Analysis System (ADA), maintained by the FAA's Office of Aviation Policy and Plans (FAA-APO).

APPENDIX D

Average Unit Costs of Instrument Flight Disruptions

I. Introduction

Weather-caused flight disruptions -- delays, cancellations, diversions and overflights -- impose economic penalties on both aircraft operators and users. This appendix outlines the derivation of average unit economic costs of instrument flight disruptions based on typical operating scenarios of prospective nonprecision instrumented RVR candidate runways. The analysis is taken from References D-1 and D-2 and modified to reflect current investment criteria development practices and 1988 critical values.

When the weather is or forecast to be below landing minima at the destination airport, the pilot can do one of four things depending upon the circumstances: (1) circle the airport until conditions improve (delay); (2) fly to a nearby airport where conditions are better (diversion); (3) in the case of a multi-legged scheduled flight, continue to the next scheduled stop (overflight); or (4) if poor weather is forecast for an extended period, cancel the flight at the departure airport (cancellation). When the weather is or forecast to be below takeoff minimum at the departure airport, the pilot can do one of two things: (1) wait until conditions improve (delay); or (2) cancel the flight (cancellation).

The unit costs of these types of flight disruption are developed separately for scheduled commercial aircraft operations, nonscheduled commercial aircraft operations, and noncommercial aircraft operations. While these costs are presented separately for hub and non-hub airports, only the costs for hub airports are relevant to the criteria developed in this report -- airports that are prospective candidates for RVR establishment on nonprecision instrumented runways.

II. Organization of Appendix

The contents and organization of this appendix are outlined below:

III. Average Unit Costs of Instrument Approach Disruptions

A. Scheduled Commercial Aircraft Operations

1. Scenario Development

Disruption of scheduled commercial aircraft flights vary depending on the length of the flight and whether or not the destination is a hub or non-hub airport. In long-haul flights, scheduled commercial operators seldom cancel because the destination airport is forecast to be closed. If on arrival the destination airport is forecast to be open within thirty minutes or so, the aircraft likely will hold. Otherwise, it will likely divert to another airport. Short- and medium-haul flights tend to take delays on the ground at the departure airport to conserve fuel and to ease congestion at the destination airport. This saves equipment operating cost but neither crew costs or the costs of passenger delay. If below-minima weather is forecast to persist at the destination airport, the flight may be canceled. If the airport is an intermediate stop along a route it may be overflown, creating a diversion for passengers intending to deplane and a cancellation for those expecting to board the aircraft.

Airport facilities also affect flight scenarios. Large airports are more likely to have precision approach procedures with lower landing minima. With lower minima, the chance that the weather will improve sufficiently in the short term is greater. Additionally, larger airports are served by larger aircraft on average than are smaller airports, making diversion or cancellation costs relatively higher. Consequently, flights destined to large airports are more likely to be delayed, rather than diverted or canceled, than are flights destined to smaller airports. Because of these differences, flight disruption cost estimating equations are developed separately for hub and non-hub airports.

2. Delays

Based on National Airspace Command Center (NASCOM) delay data, delays are assumed to average 45 minutes at hub airports and 30 minutes at non-hub airports. For purposes of the following analysis, it is assumed that the 45 minute delay for hub airports consists of 15 minutes airborne delay and 30 minutes ground delay, based on the FAA's Central Flow Control goal to limit airborne delay to an average of 15 minutes. For non-hub airports, the 30 minute delay is apportioned between airborne delay of 10 minutes and ground delay of 20 minutes.

a. Costs Associated with Passengers

Passengers on a delayed flight are assumed to be delayed 45 minutes at hub airports and 30 minutes at non-hub airports. Passengers on a following

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* NASCOM compiles statistics only for flight delays exceeding 15 minutes. NASCOM data is considered appropriate for this analysis since weather-caused flight disruptions are typically of this duration or longer.

flight may also be delayed because of the aircraft's late arrival. Equipment turnaround time, however, normally includes about 15 minutes of slack time. By foregoing scheduled slack time at subsequent intermediate stops, delayed flights are able to make up some lost time. Nevertheless, boarding passengers would still have waited for the delayed flight and be delayed as much as passengers on the preceding legs, less the time made up by foregone slack time.

An expression for passenger delay can be derived by examining what happens to each passenger on an aircraft when it is delayed and to each subsequent passenger. Based on a sample examination of the Official Airline Guide (Reference D-3), an aircraft arriving at a destination has, on average, one additional destination to serve. Given a delay on the initial leg of 'L' minutes, the 'n' passengers on that leg experience an L-minute delay. On the remaining leg of the flight, the passengers experience a delay of L-15 minutes. The total approximate delay for hub airports is therefore n x (2L-15). Assuming L equals 45 minutes at hub airports, the total delay is 1.25 hours x n passengers.

The situation is slightly different at non-hub airports, since it is assumed that half of the passengers are thru-passengers and are delayed only once. For a 30 minute delay on the leg to the non-hub destination, all of the passengers are assumed to be delayed thirty minutes (n x 30). The n/2 boarding passengers on the next leg get the benefit of the 15 minute foregone slack time and are delayed n/2 x 15 minutes. But the n/2 thru-passengers who experienced the initial 30 minute delay will enjoy the 15 minutes worth of slack time that is foregone, thus reducing their total delay to 15 minutes also. The total approximate delay for non-hub airports, therefore, is (n/2 x 30) + (n/2 x 15) + (n/2 x 15) = 15n + 7.5n + 7.5n = 30n or .5 hours x n passengers.

b. Costs Associated with Aircraft Operation

When an aircraft is delayed on the ground the carrier incurs crew costs and while airborne full aircraft variable operating costs (crew, fuel and oil, and variable maintenance costs). Ground delay costs may be partially offset by foregoing scheduled slack time, so the 30 minute estimated ground delay is reduced to 15 minutes. From Reference D-4 (as adjusted to current price levels), crew costs on average represent approximately 28% of total aircraft variable operating costs (see also Table E-1 of Appendix E). Using the term AOC_1 for weighted average hourly variable operating costs of scheduled commercial aircraft at hub airports, the following expressions result:

Airborne delay	.25 hours x AOC_1
Ground delay	.25 hours x AOC_1 x .28
Total	.32 x AOC_1

For non-hub airports, with an average 30 minute delay apportioned between airborne delay of 10 minutes and ground delay of 20 minutes less 15 minutes of foregone slack time, the following expressions result, with AOC_2 representing the weighted average hourly variable operating costs of scheduled commercial aircraft at non-hub airports:

Airborne delay	$.17$ hours x AOC_2
Ground delay	$.08$ hours x AOC_2 x $.28$
Total	$.19 \times AOC_2$

c. Summary

Combining the costs associated with passengers and the variable costs associated with aircraft operation, the total costs per delayed scheduled commercial aircraft, where V_{PT} represents the hourly value of a passenger's time, are estimated to be:

At hub airports: $(1.25\ V_{PT})\ n + 0.32\ AOC_1$

At non-hub airports: $(.5\ V_{PT})\ n + 0.19\ AOC_2$

3. Cancellations

Unless extremely poor weather is forecast to remain for several hours, scheduled commercial aircraft operators generally do not cancel flights. But given a flight cancellation, the carrier incurs passenger handling expenses and passengers suffer delay. The carrier also loses revenue from the flight while avoiding aircraft variable operating costs.

a. Costs Associated with Aircraft Operation

There are two cancellation costs which are proportional to hours of aircraft operation -- the costs avoided when the operator does not conduct the flight and the costs incurred when the aircraft must be repositioned for a future flight.

Trunk airlines are typical of those operating at hub airports, while local service airlines are typical of those operating at non-hub airports. An average trunk airline flight duration of 1.25 hours is assumed as the hours of operation avoided by a flight canceled at a hub airport. An average local service flight duration of 0.58 hours is assumed for non-hub airports.

Aircraft sometimes must be repositioned after a flight cancellation. An average of 1/2 hour extra flying time for repositioning is assumed. It is further estimated that 1/3 of canceled aircraft must be repositioned. Averaged for all cancellations, this yields 10 minutes extra flying time per cancellation (1/2 hour applied to 1/3 of the cancellations).

The following expressions of scheduled commercial aircraft cancellation (net negative) costs associated with aircraft operation result from the above analysis:

	Hub Airports	Non-Hub Airports
Repositioning aircraft (1/6 hour)	$+0.167\ AOC_1$	$+0.167\ AOC_2$
Less AOC savings	$-1.25\ AOC_1$	$-0.58\ AOC_2$
Total	$-1.083\ AOC_1$	$-0.413\ AOC_2$

b. Costs Associated with Passengers

There are two cancellation costs associated with passengers - lost revenue and passenger handling expenses, which are costs to the operator, and delay, which is a cost to the passenger.

The prospective passenger must decide whether to schedule another flight, cancel the trip altogether, or seek an alternate mode of transportation. If the passenger elects to wait for the next available flight, the carrier retains the passenger's ticket revenue with little added expense, since flights do not generally operate at full capacity. If the passenger does not continue by air, the revenue is lost by the operator. Estimates of the percentage of passengers who, after a cancellation, end up on another flight range from 30% for short trips to 80% on longer trips. The upper end of this range, 80%, is assumed here. This is expressible in terms of a per passenger cost to scheduled commercial aircraft operators as 20% of the average revenue per passenger, or .2 RPC.

Based on conversations with airline operations personnel, passengers waiting for flights that are later cancelled can easily have already spent two hours at an airport waiting for the weather to improve. After the weather improves, passengers must wait for the next available flight which can easily add an additional three hours of delay. It is assumed then that a cancelled flight results in an average total delay of five hours per passenger. This delay applies to the estimated 80 percent of passengers who continue with their original plans to fly and also to the remaining passengers who divert to surface modes of transportation.

Scheduled commercial aircraft cancellation costs associated with passengers on a per passenger basis are then:

Passenger handling expenses		V_{CLC}	
Revenue loss			.2 RPC
"Lost" passenger time (5 hrs.)	$5\ V_{PT}$		
Total	$5\ V_{PT} + V_{CLC} + .2\ RPC$		

c. Summary

Combining the variable costs associated with aircraft operation and the costs associated with passengers, the total costs per scheduled commercial aircraft cancellation are estimated to be:

At hub airports: $(5\ V_{PT} + V_{CLC} + .2\ RPC)n - 1.083\ AOC_1$

At non-hub airports: $(5\ V_{PT} + V_{CLC} + .2\ RPC)n - 0.413\ AOC_2$

It is additionally estimated that one half of the time cancellation of a flight results in cancellation of the following trip which the aircraft was scheduled to serve. Therefore, the above expressions are multiplied by 1.5:

At hub airports: $1.5\ ((5\ V_{PT} + V_{CLC} + .2\ RPC)n - 1.083\ AOC_1)$

At non-hub airports: $1.5\ ((5\ V_{PT} + V_{CLC} + .2\ RPC)n - 0.413\ AOC_2)$

4. Diversions

a. Costs Associated with Aircraft Operation

Arriving aircraft may divert to another airport if below-minima weather is forecast for an extended period of time. Additional flying time in holding over the original destination airport and flying to an alternate destination is estimated to average one hour. After the weather improves, the aircraft usually must be ferried to another airport before it resumes scheduled operations, requiring an additional estimated half hour. The total additional flight time per diversion is therefore estimated to be 1-1/2 hours at an aircraft variable operating cost of 1.5 AOC_1 for hub airports and 1.5 AOC_2 for non-hub airports.

b. Costs Associated with Passengers

Each passenger immediately "loses" one hour because of additional flight time. To this must be added the additional time required for the passenger to reach his desired destination. This may take the form of air or surface transportation and may involve the operator providing passengers with meals and overnight lodging. If the return trip is by air, an extra hour of flight time is assumed plus two hours of waiting for the destination airport to accept arriving aircraft. Similar amounts of time are likely for surface transportation. Total time lost due to a flight disruption thus totals an estimated four hours per passenger. Airlines incur extra passenger-handling expenses for food, housing, and return-trip fare. The per passenger expense is thus:

Passenger handling expenses	V_{DVC}
"Lost" passenger time (4 hrs.)	$4\ V_{PT}$
Total	$4\ V_{PT} + V_{DVC}$

c. Secondary Effects of Diversions

At non-hub airports there is a secondary effect of diversions because the following trip on which the aircraft was scheduled to depart may be canceled. From information obtained from airline data, it is estimated that this occurs on half of non-hub flights. Cancellation costs associated with passengers on a per passenger basis, as developed above in Section III-A-3-b, are:

$$5\ V_{PT} + V_{CLC} + .2\ RPC$$

The aircraft variable operating cost savings from avoiding the canceled leg are 0.58 AOC_2 (from Section III-A-3-a above). Combining these terms and multiplying by 0.5 to account for the estimated half of flights that are affected, the secondary effect of a scheduled commercial aircraft operation diversion at a non-hub airport is estimated to be:

$$0.5\ ((5\ V_{PT} + V_{CLC} + .2\ RPC)n - 0.58\ AOC_2)$$

d. Summary

Combining the expressions derived above, the costs associated with the

diversion of a scheduled commercial aircraft operation are estimated to be:

At hub airports: $(4\ V_{PT} + V_{DVC})n + 1.5\ AOC_1$

At non-hub airports:

$$(4\ V_{PT} + V_{DVC})n + 1.5\ AOC_2 + 0.5\ ((5\ V_{PT} + V_{CLC} + .2\ RPC)n - 0.58\ AOC_2)$$

$$= (6.5\ V_{PT} + V_{DVC} + .5\ (V_{CLC} + .2\ RPC))n + 1.21\ AOC_2$$

5. Overflights

Overflights are assumed to apply at non-hub airports only. An overflight reduces aircraft variable operating costs since, when a stop is bypassed and the aircraft proceeds directly to its next destination, total flying time is reduced. These savings are offset in those instances when the pilot holds for a few minutes over the intended destination while deciding whether or not to attempt a landing.

An overflight results in a diversion for passengers intending to deplane and a cancellation for passengers intending to board the aircraft. The aircraft operator incurs extra passenger handling expenses when stops are overflown, just as it does with diversions and cancellations, and passengers, whether enplaning or deplaning, experience delays. For these reasons, an overflight is equated to a diversion plus a cancellation and, except for increased aircraft variable operating costs, costed accordingly. Passenger costs of a scheduled commercial aircraft overflight are therefore estimated to be:

For a diverted passenger:				
Passenger handling expenses		V_{DVC}		
"Lost" passenger time (4 hrs.)	$4\ V_{PT}$			
Subtotal	$4\ V_{PT} +$	V_{DVC}		
For a canceled passenger:				
Passenger handling expenses			V_{CLC}	
"Lost" passenger time (5 hrs.)	$5\ V_{PT}$			
Revenue loss				$.2\ RPC$
Subtotal	$5\ V_{PT} +$		$V_{CLC} +$	$.2\ RPC$
Total:	$(9\ V_{PT} + V_{DVC} + V_{CLC} + .2\ RPC)\ n$			

6. Relative Distribution of Approach Disruptions

In this section the relative distribution of approach disruptions is derived so that the cost equations derived above can be weighted and combined into single and separate expressions for hub and non-hub airports.

Statistics summarized in Reference D-1 suggest average cancellation rates per certificated route carrier departure of 2.5% and 8.2% at hub and non-hub airports respectively. On an average annual basis, about 2/3 of scheduled commercial aircraft operation cancellations are due to weather. Scheduled commercial aircraft operation diversions tend to be about 1/10 as frequent

as cancellations and about 5/6 of these diversions are caused by weather:

Weather-caused cancellations	=	2.5% x 2/3
	=	1.7% of all flights
Weather-caused diversions	=	2.5% x 1/10 x 5/6
	=	0.2% of all flights

An FAA-APO report, Airfield and Airspace Capacity/Delay Policy Analysis (Reference D-5), estimates that about 6.6% of all scheduled commercial aircraft departures and about 13.2% of all scheduled commercial aircraft arrivals are delayed 15 minutes or longer. Data collected by the FAA through its NASCOM program shows that of delays to IFR aircraft of over 30 minutes, an average of 29% are due to weather. Applying the NASCOM percentage to the APO delay data suggests that approximately 3.8% of all flights are delayed because of weather (13.2% x 29%).

Recapitulating for hub airports:

Weather-Caused Flight Disruption	Distribution of Approach Disruptions of Scheduled Commercial Service Operations at Hub Airports: Percent of all Flights	Normalized Distribution %
Delays	3.8	67
Cancellations	1.7	30
Diversions	0.2	3
	---	---
	5.7	100

Assuming an average cancellation rate of 8.2% for scheduled commercial aircraft flights into non-hub airports, estimates for the percentage of weather-caused cancellations and diversions can be derived following the method used above for hub airports:

Weather-Caused Cancellations	=	8.2% x 2/3
	=	5.5% of all flights
Weather-Caused Diversions	=	8.2% x 1/10 x 5/6
	=	0.7% of all flights

An informal survey of several small scheduled commercial aircraft operators revealed that 20 to 30% of cancellations result from overflights. Applying the median of 25% to the 5.5% for cancellations yields overflights as accounting for 1.4% of all flights, with 4.1% remaining as pure cancellations. The delay experience at non-hub airports is assumed to be similar to that at hub airports.

Summarizing for non-hub airports:

Weather-Caused Flight Disruption	Distribution of Approach Disruptions of Scheduled Commercial Service Operations at Non-Hub Airports: Percent of all Flights	Normalized Distribution %
Delays	3.8	38
Cancellations	4.1	41
Diversions	0.7	7
Overflights	1.4	14
	----	---
	10.0	100

7. Summary

Total estimated costs associated with weather-caused approach disruptions of scheduled commercial aircraft flights can be determined by weighting the cost of each type of disruption by its relative frequency of occurrence and combining the respective results into one equation. For each equation, each term is multiplied below by its appropriate weight and a product obtained. Like variables are then summed and grouped into a single equation, representing the weighted average unit cost of a scheduled commercial aircraft approach disruption. The individual equations, their respective weights, and the resulting average equations for hub and non-hub airports are summarized below:

Hub Airports:

Disruption	Cost Equation	Weight
Delays	$(1.25\ V_{PT})n + 0.32\ AOC_1$	0.67
Cancellations	$1.5\ ((5\ V_{PT} + V_{CLC} + .2\ RPC)n - 1.083\ AOC_1)$	0.30
Diversions	$(4\ V_{PT} + V_{DVC})n + 1.5\ AOC_1$	0.03

		1.00

The average unit cost of a scheduled commercial aircraft approach disruption at a hub airport is thus estimated to be:

$$(3.21\ V_{PT} + 0.03\ V_{DVC} + 0.45\ (V_{CLC} + .2\ RPC))n - 0.24\ AOC_1$$

Non-Hub Airports:

Disruption	Cost Equation	Weight
Delays	$(.5\ V_{PT})n + 0.19\ AOC_2$	0.38
Cancellations	$1.5\ ((5\ V_{PT} + V_{CLC} + .2\ RPC)n - 0.413\ AOC_2)$	0.41
Diversions	$(6.5\ V_{PT} + V_{DVC} + .5(V_{CLC} + .2\ RPC))n + 1.21 AOC_2$	0.07
Overflights	$(9\ V_{PT} + V_{DVC} + V_{CLC} + .2\ RPC)n$	0.14

		1.00

The average unit cost of a scheduled commercial aircraft approach disruption at a non-hub airport is thus estimated to be:

$$(4.98\ V_{PT} + 0.21\ V_{DVC} + .79\ (V_{CLC} + .2\ RPC))n - 0.10\ AOC_2$$

B. Nonscheduled Commercial Aircraft

1. Scenario Development

Little data exists on the behavior of nonscheduled commercial aircraft operators faced with weather-caused flight disruptions. Nonscheduled commercial aircraft operators are assumed to operate in much the same manner as scheduled commercial aircraft operators at non-hub airports described above in Section III-A.

2. Delays

a. Costs Associated with Aircraft Operation

Nonscheduled commercial aircraft delay duration is assumed to be the same as non-hub scheduled commercial aircraft operations, with an average 30 minute delay apportioned between airborne delay of 10 minutes and ground delay of 20 minutes. No foregone slack time, however, is assumed. From Reference D-4 (as adjusted to current price levels), crew costs on average represent approximately 36% of total aircraft variable operating costs (see also Table E-1 of Appendix E). Aircraft variable operating costs for weather-caused nonscheduled commercial aircraft operations delays are then:

Airborne delay	$.17$ hours x AOC_3
Ground delay	$.33$ hours x AOC_3 x 0.36

Total:	$.29$ x AOC_3

where AOC_3 represents nonscheduled commercial aircraft variable operating costs per airborne hour.

b. Costs Associated with Passengers

Nonscheduled commercial aircraft passenger delay duration is assumed to be identical to that for scheduled commercial aircraft operations at non-hub airports -- 0.5 hour per passenger.

c. Summary

The total cost per delayed nonscheduled commercial aircraft operation is thus estimated to be:

$$(0.5\ V_{PT})n + .29\ AOC_3$$

3. Cancellations, Diversions and Overflights

Costs for nonscheduled commercial aircraft cancellations, diversions, and overflights are estimated to be the same as those for scheduled commercial aircraft at non-hub airports, except for the adjustments noted below. All values for lost passenger time are taken as half of those associated with scheduled commercial aircraft, because as a rule the number of passengers is smaller, the nonscheduled commercial aircraft organization is smaller, and final decisions regarding the handling of diverted or canceled passengers are made more quickly. Returning a passenger to his original destination is also less time consuming since stage lengths are shorter. For cancellations, another difference is the percentage of revenue recovery used in the flight cancellation scenario. On average, about 70% of nonscheduled commercial aircraft passengers cancel their trips or use other means of travel when a flight is canceled. Finally, nonscheduled commercial aircraft operators are presumed not to reimburse passengers for expenses when a flight is canceled due to poor weather:

Cancellations: $1.5\ ((2.5\ V_{PT} + .7\ RPT)n - 0.413\ AOC_3)$
Diversions: $(3.0\ V_{PT} + V_{DVT})n + .5(.7\ RPT))n + 1.21\ AOC_3$
Overflights: $(4.5\ V_{PT} + V_{DVT} + .7\ RPT)n$

where, for nonscheduled commercial aircraft operations, RPT is the average revenue per passenger and V_{DVT} is the passenger handling expense for diverted passengers.

4. Summary

Nonscheduled commercial aircraft approach disruption costs and the relative weight of each are summarized below:

Disruption	Cost Equation	Weight
Delays	$(.5\ V_{PT})n + 0.29\ AOC_3$	0.38
Cancellations	$1.5\ ((2.5\ V_{PT} + .7\ RPT)n - 0.413\ AOC_3)$	0.41
Diversions	$(3\ V_{PT} + V_{DVT})n + .5\ (.7\ RPT) + 1.21\ AOC_3$	0.07
Overflights	$(4.5\ V_{PT} + V_{DVT} + .7\ RPT)n$	0.14

		1.00

The average unit cost of a nonscheduled commercial aircraft approach disruption is thus estimated to be:

$$(2.57\ V_{PT} + 0.21\ V_{DVT} + 0.79\ (.7\ RPT))n - 0.06\ AOC_3$$

C. Noncommercial Aircraft Operations

1. Scenario Development

Most flight disruption impacts due to weather in noncommercial aircraft operations are felt by business travelers flying in relatively large aircraft equipped for IFR operations. The pattern of flight disruptions experienced in noncommercial aircraft operations is probably similar to that for nonscheduled commercial aircraft, except that there are few secondary effects. The impact of flight disruptions on passengers is less because the aircraft is generally available for use as soon as the weather clears. Because of the greater number of airports at which noncommercial aircraft operate, diversion times are less. Interrupted trip expenses are incurred for meals and overnight accommodations in some cases.

Additional aircraft variable operating costs (AOC_4) and interrupted trip expenses for canceled (V_{CLG}) and diverted (V_{DVGM}) passengers represent the major cost impacts resulting from approach disruptions of noncommercial aircraft. No distinction is made between hub and non-hub airports for noncommercial aircraft flight disruptions.

2. Delays

Noncommercial aircraft delay duration is assumed to be the same as that for nonscheduled commercial aircraft. Variable operating costs associated with aircraft operation are 0.29 AOC_4 and those with passengers are .5 V_{PT}, for a total of:

$$(0.5\ V_{PT})\ n + 0.29\ AOC_4$$

3. Cancellations

When a noncommercial aircraft flight is forced to cancel due to poor weather, no additional flying time, lost revenue, or passenger handling expense is involved. What remains from the nonscheduled commercial aircraft operation equation is merely $2.5V_{PT}\ n$.

4. Diversions

The cost of a noncommercial aircraft diversion is again similar to nonscheduled commercial aircraft, but without the secondary effects. The equation is therefore:

$$(2.0\ V_{PT} + V_{DVGM})n + 1.5\ AOC_4$$

5. Summary

Noncommercial aircraft flight disruption costs are weighted similar to those for scheduled commercial aircraft operations at non-hub airports and

nonscheduled commercial aircraft operations, except the percentage for overflights is added to cancellations because overflights are presumed not to occur.

Disruption	Cost Equation	Weight
Delays	$(0.5\ V_{PT})n + 0.29\ AOC_4$	0.38
Cancellations	$2.5\ V_{PT}\ n$	0.55
Diversions	$(2.0\ V_{PT} + V_{DVGM})n + 1.5\ AOC_4$	0.07

		1.00

The average unit cost of a noncommercial aircraft approach disruption is thus estimated to be:

$$(1.71\ V_{PT} + 0.07\ V_{DEFT})n + 0.22\ AOC_4$$

D. Summary

The following equations are reproduced from the preceding text:

Scheduled Commercial Aircraft Operations:

Hubs: $(3.21\ V_{PT} + 0.03\ V_{DVC} + 0.45\ (V_{CLC} + .2\ RPC))n - 0.24\ AOC_1$

Non-hubs: $(4.98\ V_{PT} + 0.21\ V_{DVC} + 0.79\ (V_{CLC} + .2\ RPC))n - 0.10\ AOC_2$

Nonscheduled Commercial Aircraft Operations:

$$(2.57\ V_{PT} + 0.21\ V_{DVT} + 0.79\ (.7\ RPT))n - 0.06\ AOC_3$$

Noncommercial Aircraft Operations:

$$(1.71\ V_{PT} + 0.07\ V_{DVGM})n + 0.22\ AOC_4$$

E. Variable Values

Average weather-caused approach disruption costs are estimated in generalized form in this appendix to permit substitution of new values for the variables as their values change and are updated over time. Specific costs can be estimated by substituting the appropriate value for each variable and deriving the solution. The following values, taken from Appendix E of this report, are weighted averages typical of prospective candidate airports for RVR on nonprecision instrumented runways. Dollar-denominated values are expressed in terms of 1988 dollars:

V_{PT} - Hourly value of a passenger's time, $24.50

n - Weighted average number of passengers/occupants per flight leg:

Scheduled Commercial:	Hub Airports	- 97.4 passengers
	Non-Hub Airports	- Not applicable
Nonscheduled Commercial		- 3.6 passengers
Noncommercial		- 3.1 occupants

AOC_1 - Scheduled commercial aircraft weighted average variable operating cost per airborne hour at hub airports - $1,796

AOC_2 - Scheduled commercial aircraft weighted average variable operating cost per airborne hour at non-hub airports - Not applicable in this report

AOC_3 - Nonscheduled commercial aircraft weighted average variable operating cost per airborne hour - $226

AOC_4 - Noncommercial aircraft weighted average variable operating cost per airborne hour - $133

V_{CLC} - Scheduled commercial aircraft passenger handling expense for canceled passengers (including overnight lodging) - $52

V_{DVC} - Scheduled commercial aircraft passenger handling expense for diverted passengers (including overnight lodging, meals, and transportation to original destination) - $76

V_{DVT} - Nonscheduled commercial aircraft passenger handling expense for diverted passengers (including overnight lodging and transportation to original destination) - $64

V_{DVGM} - Noncommercial aircraft passenger handling expense for diverted passengers - $64

RPC - Scheduled commercial aircraft average revenue per passenger - $92 (average trip length of 770 miles applied to average ticket cost per passenger mile of 12 cents)

RPT - Nonscheduled commercial aircraft average revenue per passenger - $21 (average trip length of 130 miles applied to average ticket cost per passenger mile of 16 cents)

F. Unit Costs of Instrument Approach Disruptions

Substituting the values in Section III-E into the equations summarized in Section III-D and solving yields the following unit costs of instrument approach disruptions in 1988 dollars:

Scheduled Commercial Aircraft Operations - Hub	-	$10,537
Scheduled Commercial Aircraft Operations - Non-hub	-	Inappl.
Nonscheduled Commercial Aircraft Operations	-	303
Noncommercial Aircraft Operations	-	196

IV. Average Unit Costs of Instrument Departure Disruptions

A. Introduction

The general methodology outlined in Section III of this appendix for estimating the average unit costs of instrument approach disruptions is also used in this section for estimating the average unit costs of instrument departure disruptions. While the same general methodology is used, several differences exist. The most significant of these are that the types of flight disruption are limited to delays and cancellations (diversions and overflights are not relevant) and only scheduled commercial aircraft operations and nonscheduled commercial aircraft operations generate RVR takeoff benefits. In the interest of simplicity and avoiding repetition, the discussion is generally limited to differences from approach disruptions and assumes reader familiarity with Section III of this appendix.

B. Scheduled Commercial Aircraft Operations

1. Delays

Delay durations at the departure airport are assumed to average 45 minutes at hub airports and 30 minutes at non-hub airports, based on the NASCOM sample discussed in Section III-A-2. The costs associated with passengers, therefore, are $.75 \times V_{PT} \times n$ for hub airports and $0.5 \times V_{PT} \times n$ for non-hub airports. With respect to aircraft operation, only crew costs, as opposed to full aircraft variable operating costs, are incurred since the entire duration of delay takes place on the ground.

Summarizing scheduled commercial aircraft operation delay costs:

At hub airports:
$$(.75\ V_{PT})n + (.75 \text{ hours} \times .28\ AOC_1) = (.75\ V_{PT})n + 0.21\ AOC_1$$

At non-hub airports:
$$(.5\ V_{PT})n + (.5 \text{ hours} \times .28\ AOC_2) = (.5\ V_{PT})n + 0.14\ AOC_2$$

2. Cancellations

The costs of scheduled commercial aircraft cancellations were addressed earlier in Section III-A-3 and are repeated below. It is noted that V_{CLC} may not apply to all passengers, e.g., those scheduled to enplane a flight where the cancellation takes place. No allowance is explicitly made for this, however, in light of its insignificant impact on total cost per flight disruption .

At hub airports: $1.5((5\ V_{PT} + V_{CLC} + .2\ RPC)n -1.083\ AOC_1)$

At non-hub airports: $1.5((5\ V_{PT} + V_{CLC} + .2\ RPC)n -0.413\ AOC_2)$

3. Relative Distribution of Departure Disruptions

Within the accuracy of this analysis, the relative distribution of departure disruptions may be reasonably estimated by normalizing the relative frequency of approach disruptions as derived in Section III-A-6.

Weather-Caused Flight Disruption	Percent of all Flights (From Section III-6)	Normalized Distribution % for Application to Departures
Hub Airports		
Delays	3.8	69
Cancellations	1.7	31
	5.5	100
Non-Hub Airports		
Delays	3.8	48
Cancellations	4.1	52
	7.9	100

4. Summary

Weighting the unit cost equations of scheduled commercial aircraft departure delays and cancellations as derived above by their estimated relative frequency of occurrence results in the following equations:

Hub Airports:

Disruption	Cost Equation	Weight
Delays	$(.75\ V_{PT})n + 0.21\ AOC_1$	0.69
Cancellations	$1.5\ ((5\ V_{PT} + V_{CLC} + .2\ RPC)n - 1.083\ AOC_1)$	0.31
Average	$(2.84\ V_{PT} + 0.47\ (V_{CLC} + .2\ RPC))n - 0.36\ AOC_1$	1.00

Non-Hub Airports:

Disruption	Cost Equation	Weight
Delays	$(.5\ V_{PT})n + 0.14\ AOC_2$	0.48
Cancellations	$1.5\ ((5\ V_{PT} + V_{CLC} + .2\ RPC)n - 0.413\ AOC_2)$	0.52
Average	$(4.14\ V_{PT} + 0.78\ (V_{CLC} + .2\ RPC))n - 0.25\ AOC_2$	1.00

C. Nonscheduled Commercial Aircraft Operations

1. Delays

The costs associated with passengers delayed on a nonscheduled commercial aircraft departure are assumed to be the same as those for passengers delayed on an approach -- $0.5 \times V_{PT} \times n$. With respect to aircraft operation, only crew costs, as opposed to full aircraft variable operating costs, are incurred since the entire duration of delay takes place on the ground. Summarizing nonscheduled commercial aircraft delay costs:

$$(0.5\ V_{PT})n + .5 \text{ hours} \times .36\ AOC_3$$

$$= (0.5\ V_{PT})n + .18\ AOC_3$$

2. Cancellations

The costs of nonscheduled commercial aircraft cancellations were addressed earlier in Section III-B-3. They are reproduced below:

$$1.5\ (2.5\ V_{PT} + .7\ RPT)n\ -0.413\ AOC_3)$$

3. Summary

Weighting the unit cost equations of nonscheduled commercial aircraft delays and cancellations as derived above by their estimated relative frequency of occurrence results in the following equations:

Disruption	Cost Equation	Weight
Delays	$(0.5\ V_{PT})n + .18\ AOC_3$	0.48
Cancellations	$1.5\ ((2.5\ V_{PT} + .7\ RPT)n\ -0.413\ AOC_3)$	0.52

Average	$(2.19\ V_{PT} + .5\ RPT)n\ -0.24\ AOC_3$	1.00

D. Summary

The following equations are reproduced from the preceding text:

Scheduled Commercial Aircraft Operations:

Hub Airports: $(2.84\ V_{PT} + 0.47\ (V_{CLC} + .2\ RPC))n\ -0.36\ AOC_1$

Non-Hub Airports: $(4.14\ V_{PT} + 0.78\ (V_{CLC} + .2\ RPC))n\ -0.25\ AOC_2$

Nonscheduled Commercial Aircraft Operations:

$$(2.19\ V_{PT} + .5\ RPT)n\ -\ 0.24\ AOC_3$$

E. Unit Costs of Instrument Departure Disruptions

Substituting the values in Section III-E into the equations summarized above yields the following unit costs of instrument departure disruptions in 1988 dollars:

Scheduled Commercial Aircraft Operations:		
Hub Airports	-	\$9,353
Non-Hub Airports	-	Inappl.
Nonscheduled Commercial Aircraft Operations	-	\$ 177

References for Appendix D

D-1 "Benefits of Reduced Flight Disruption," Appendix B to Report Number FAA-APO-82-10, Establishment and Discontinuance Criteria for Precision Landing Systems, September 1983. Modified here for adherence to current investment criteria development practices, expanded to account for instrument departures, and updated to incorporate 1988 critical values.

D-2 Establishment and Discontinuance Criteria for Runway Visual Range at Category I Precision Landing System Runway, Report Number FAA-APO-87-9, January 1987.

D-3 Official Airline Guide.

D-4 Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs, Report Number FAA-APO-81-3, September 1981. Updated by Bulletin Number FAA-APO-84-3, June 1984, same title.

D-5 Airfield and Airspace Capacity/Delay Policy Analysis, FAA Office of Aviation Policy and Plans, November 1981.

APPENDIX E

Critical Values

The FAA uses various economic values, commonly referred to as "critical values," in the economic evaluation of many of its investment and regulatory programs. Table E-1 outlines the critical values that are applicable in this report, based on and in terms of weighted averages of prospective candidate airports for RVR on nonprecision instrumented runways. Dollar-denominated critical values in Table E-1 are expressed in 1988 dollars. More detailed discussions of these and other critical values used in FAA's economic analyses are outlined in References E-1 and E-2.

While the critical values outlined in Table E-1 are presented in terms of weighted averages, THE AVIATION DATA AND ANALYSIS SYSTEM (ADA) RELIES UPON SITE-SPECIFIC DATA TO THE EXTENT AVAILABLE IN ACTUAL BENEFIT/COST SCREENING. Ideally, if the cognizant regional office or other criteria user can furnish further detailed information pertinent to the specific candidate site being evaluated, the need to use estimates based on averages can be further reduced. It is recommended that average values be used only if site-specific data are unavailable or cannot be reasonably estimated.

TABLE E-1

Critical Values
(Dollar-Denominated Values in 1988 Dollars)

Variable Name	Critical Value Description	Value
V_{PT}	Hourly value of an air traveller's time (Source: Reference E-2)	$24.50
n	Weighted average number of passengers/occupants per flight leg (Source: Reference E-5):	
	Scheduled Commercial: Hub Airports (passengers)	97.4
	Nonscheduled Commercial (passengers)	3.6
	Noncommercial (itinerant occupants)	3.1
AOC_1	Scheduled commercial aircraft weighted average variable operating cost per airborne hour at hub airports (Sources: References E-2 and E-5):	
	Crew cost	$ 503
	Variable fuel and oil cost	1,035
	Variable maintenance cost	258
	Total	$1,796

TABLE E-1 (Continued)

Critical Values
(Dollar-Denominated Values in 1988 Dollars)

Variable Name	Critical Value Description	Value
AOC_2	Scheduled commercial aircraft weighted average variable operating cost per airborne hour at non-hub airports	Inappl.
AOC_3	Nonscheduled commercial aircraft weighted average variable operating cost per airborne hour (Sources: References E-2 and E-5):	
	Crew cost	$ 82
	Variable fuel and oil cost	74
	Variable maintenance cost	71
	Total (not equal to detail due to rounding)	$ 226
AOC_4	Noncommercial aircraft weighted average variable operating cost per airborne hour - itinerant operations (Sources: References E-2 and E-5):	
	Crew cost (N/A; crew included in nr of occupants)	Inappl.
	Variable fuel and oil cost	84
	Variable maintenance cost	49
	Total	$ 133
V_{CLC}	Scheduled commercial aircraft passenger handling expense for canceled passengers (including overnight lodging) (Source: Reference E-3)	$52
V_{DVC}	Scheduled commercial aircraft passenger handling expense for diverted passengers (including overnight lodging, meals, and transportation to original destination) (Source: Reference E-3)	$76
V_{DVT}	Nonscheduled commercial aircraft passenger handling expense for diverted passengers (including overnight lodging and transportation to original destination) (Source: Reference E-3)	$64
V_{DVGM}	Noncommercial aircraft passenger handling expense for diverted passengers (Source: Reference E-3)	$64
RPC	Scheduled commercial aircraft average revenue per passenger (average trip length of 770 miles applied to average ticket cost per passenger mile of 12 cents) (Source: Reference E-4)	$92

RPT Nonscheduled commercial aircraft average revenue per passenger (average trip length of 130 miles applied to average ticket cost per passenger mile of 16 cents) (Source: Reference E-4) $21

REFERENCES FOR APPENDIX E

E-1 Economic Analysis of Investment and Regulatory Decisions - A Guide, Report Number FAA-APO-82-1, January 1982.

E-2 Economic Values for Evaluation of Federal Aviation Administration Investment and Regulatory Programs, Report Number FAA-APO-81-3, September 1981. Updated by Bulletin Number FAA-APO-84-3, June 1984, same title.

E-3 Establishment and Discontinuance Criteria for Precision Landing Systems, Report Number FAA-APO-82-10, September 1983.

E-4 FAA Office of Aviation Policy and Plans, Planning Analysis Division, Forecast Branch (FAA-APO-110).

E-5 Work papers supporting FAA-APO draft report Establishment Criteria for Terminal Doppler Weather Radar (TDWR) System and Low-Level Wind Shear Alert System (LLWAS), May 1988.